DOWNSIDE RISK OPTIMIZATION OF THE THRIFT SAVINGS PLAN LIFECYCLE FUND PORTFOLIOS

THESIS

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Abstract

The Thrift Savings Plan (TSP), the defined benefit contribution plan for the US Government, introduced the asset allocation Lifecycle (L) Funds in August 2005. These funds seek to minimize risk and maximize expected portfolio return via mean-variance optimization (MVO).

The purpose of this thesis is to investigate and examine the efficiency of the TSP L Funds and create alternative L Fund portfolios via downside risk optimization (DRO). Whereas MVO minimizes the portfolio variance (standard deviation), DRO seeks to minimize the risk below an investor's minimal acceptable return in the market, defined as the Co-Lower Partial Moment (CLPM). The research team compares the TSP and DRO (CLPM) L Fund expected portfolio values at retirement for three typical investors. The expected portfolio values are computed using @Risk software via Monte Carlo simulation of TSP individual fund monthly returns, the L Fund quarterly target allocations, and various investor inputs.

The quantitative results and analysis of this evaluation determined that TSP participants realize higher expected portfolio values at retirement by investing into a DRO (CLPM) L Fund versus any of the TSP L Funds. To validate the findings, this thesis compares an investment stream in the L Funds from August 2005 through December 2009.

This work is dedicated to my wife. Thank you for all your patience and support in this endeavor. I couldn't ask for anyone better.

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This effort would not have been possible without the love and support from my wife. Thank you all your patience and motivation in pushing me to create something important and meaningful to so many. You are the best!

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Matthew Beck

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DOWNSIDE RISK OPTIMIZATION OF THE THRIFT SAVINGS PLAN LIFECYCLE FUND PORTFOLIOS

I: Introduction

General Background

The recession that began in December 2007 posed serious dilemmas for many investors worldwide. According to US News and World Report, actively managed stock funds lost nearly 41% on average in 2008 (Mardquardt, 2009). President Barack Obama in his address to the US Congress on February 24, 2009, said that, "our economy is in a crisis…weakened and our confidence shaken" (2009). Federal Reserve Chairman Ben Bernanke, speaking at the Federal Reserve Bank of Kansas City's Annual Economic Symposium on August 21, 2009, commented on the impact of recession that, "the world has been through the most severe financial crisis since the Great Depression" (2009). Pensions, savings, and investment accounts that Americans had worked for seemed to vanish, worrying those close to retirement and casting doubt for young investors on whether to enter or stay in the market (Sager, 2009). Because of the recession, many investors began to shy away from risk, becoming more risk-averse, as worries of inflation and the state of the economy plagued both consumer and investor confidence (Rasmussen Reports, 2009). One of the investment vehicles particularly hit hard by the recession was employee 401(k) plans. These vehicles, available for employees through their employer, are tax-deferred contribution plans which are used as a means to invest and save for retirement. Within the US Government, federal civilian employees and military members

depend on a similar tax-deferred investment vehicle for their retirement savings, the Thrift Savings Plan (TSP).

As of April 2009, the Federal Retirement Thrift Investment Board (FRTIB), the governing independent agency for the TSP, reported that approximately 85% of government employees and 37% of active duty military actively participate in the TSP (FRITB – Minutes of the Meeting, 2009:1). For those who seek a 401(k) style retirement plan, the TSP offers distinct features such as online enrollment, inter-fund transfer management, and the ability to change payroll deductions at the participant's discretion. Participants or those looking information on the TSP may go to its website, www.tsp.gov.

Despite the large amount of information available on the TSP website, many TSP participants do not have a financial management or economic background of which to help determine the best investment for retirement based on their own revealed risk preferences. To narrow the scope of possible choices, the TSP offers only five individual funds for participants to invest in. Despite this, some participants raise fundamental questions based on their specific retirement goals as well as tolerance for expected return and risk for their investments such as – *How should I choose to invest my money? Am I maximizing my expected return for the risk I am assuming?* Websites such as Morningstar.com and Google Finance as well as investment magazines like *Forbes* and *Money* offer advice for investors looking to answer questions like these. For a fee, and often a minimum investment requirement, investment firms and online brokerage companies such as *Scottrade* and *Charles Schwab* offer their knowledge databases in addition to one-on-one investment advice to clients. However, the TSP is unique. Its funds do not carry a researchable ticker symbol nor does the TSP employ fund managers

or brokers with investment advice. The participant therefore must perform all the necessary research to properly select a TSP portfolio and make the optimal investment decisions in order to meet their retirement goals.

To help combat the confusion of contributing to the TSP or selecting the correct mix of funds to best suite a participant's retirement needs and risk preference, the FRTIB devised and introduced the Lifecycle, or L, Funds on August 1, 2005. As diversified portfolios of the five individual funds, the FRTIB designed the L Funds so that participants can put their TSP investments on "cruise control," investing their entire account into a designated L Fund and allowing their contributions and the fund to be professionally managed (TSP – Lifecycle Funds Menu, 2009). However, one question remains – *Is an L Fund the best and most efficient TSP portfolio and strategy a participant can select in order to meet their desired monetary goals at retirement?*

Specific Background

The TSP is a defined contribution benefit plan available to US Government civilian employees as well as military members. It offers the benefit of investing pre-tax dollars, allows earnings to grow tax-deferred, and is similar to private sector 401(k) plans. Invested TSP monies are subject to income taxes at time of withdrawal, and can be subject to penalty taxes (10 percent) for pre-mature withdrawal. Participants are able to invest into any of the five individual TSP funds: the Government Securities Investment (G) Fund, Fixed Income Index Investment (F) Fund, Common Stock Index Investment (C) Fund, Small Capitalization Stock Index (S) Fund, or International Stock Index

Investment (I) Fund. In addition to the individual TSP funds, participants may also choose to invest into one of the five L funds, which are professionally managed asset allocation portfolios comprised of the five individual funds tailored to a specified time horizon (FRTIB – Thrift Savings Plan, 2010:1-2). Each L Fund rebalances daily to a quarterly target allocation and at the end of each annual quarter, shifts slightly to a more conservative allocation or mix of the five individual TSP funds. As such, these L Funds "roll" down an efficient frontier and become less risky (more conservative) as the fund's time horizon gets closer. The FRTIB (along with the private firm Mercer Investment Consulting, Inc) set the L Fund target allocations at their inception on August 1, 2005, and states that "putting your entire TSP account into one of the L Funds allows you to achieve the best expected return for the amount of expected risk that is appropriate for your time horizon" (FRTIB – Thrift Savings Plan, 2010:2). The FRTIB advises that participants should select the L Fund that coincides with their expected retirement or withdrawal date. If a participant chooses to invest their TSP contributions into any of the L Funds, the quarterly target allocations of each L Fund are available on the TSP website from inception through July 2040. Participants therefore know the quarterly mix of their L Fund at any time and can view the allocation path from now until retirement.

Civilian employees may contribute a whole dollar amount or percentage of basic pay via payroll deductions to any of the individual funds and/or L Funds. Based upon whether one is in the older Civil Service Retirement System or the newer Federal Employees Retirement System program, there can be agency and matching contributions that supplement civilian employee's payroll deductions. Although military members who participate in the TSP do not receive agency or matching contributions, military members

making standard payroll contributions are able to contribute up to 100% from any incentive, special or bonus pay (FRTIB - Summary, 2008:2). Contribution limitations and rules mirror those for any private-employer sponsored 401(k). In 2010, the Internal Revenue Service elective deferral contribution limit is $16,500 for employee contributions and $5,500 for catch-up contributions.

Research Problem

The purpose of this research is to analyze both the mean-variance optimization (MVO) and downside risk optimization (DRO) methods within the TSP framework. More specifically, we will compare portfolios associated with each optimization theory and dissect the TSP L Funds, of which the FRTIB argues provide the highest possible expected return for a given amount of expected risk assumed by a participant (FRTIB – TSP, 2010:1-2).

In a prior effort, Captain Christopher Blanchette attempted to develop a TSP investment tool in his Air Force Institute of Technology 2004 thesis work. Specifically, he sought to create optimal portfolios of the five individual funds that TSP participants would be able to select in order to reach their desired retirement goals. Blanchette optimized 13 different and efficient portfolios based on historic individual TSP fund returns using Modern Portfolio Theory (MPT) principles and MVO, minimizing risk (portfolio variance and/or standard deviation) for a specific level of return. With his MVO efficient portfolios, he created an investment tool using Monte Carlo simulation of monthly returns and various investor inputs (such as years to retirement and TSP

contributions). He then examined a goal program that would aid investors in selecting an appropriate portfolio based on the probability of meeting their retirement goals (Blanchette, 2004:5). However, Blanchette was unable to make his tool available to Air Force or Department of Defense personnel and his work was unable to consider the asset allocation L Funds the FRTIB first introduced in August 2005.

Building on Blanchette's 2004 thesis work, we will analyze the efficiency of the all five L Funds using MVO as well as DRO, the optimization method that underlines the principles of the Post-Modern Portfolio Theory (PMPT). Whereas MVO minimizes the portfolio's standard deviation, DRO minimizes a different but analogous measurement, the Lower-Partial Moment (LPM) or Co-Lower Partial Moment (CLPM). Instead of measuring risk above and below the expected mean as MVO does with the portfolio's variance, the LPM and CLPM calculation is the probability measurement of falling below an investor minimal required return. Thus, the DRO theory aims to minimize the potential portfolio losses below that investor required return. Both theories aspire to minimize risk and maximize an expected return, but use different measurements for risk – variance, LPM, or CLPM.

We test the FRTIB assertions that a more efficient allocation of TSP asset allocation portfolios cannot be created using both MVO and DRO methods. The FRTIB considers the allocation of each of the five L funds to be efficient, meaning a maximum expected return given an assumed level of investor risk. However, the allocations for all five L Funds were determined and their defined target allocation paths set only at inception in August 2005. The FRTIB has asserted that if participants invest their entire TSP accounts into one of the L Funds based on their retirement or withdrawal date, there

is no better allocation of the five individual funds available to achieve a maximum return for the level of risk assumed (FRTIB – Thrift Savings Plan, 2010:2). This research will analyze those assertions, seeking to build and compare an alternative asset allocation portfolios based on the same methodology and time horizons created by the TSP and FRTIB for the L Funds. We will impose both MVO and DRO methods within the MPT and PMPT frameworks, respectively, looking for efficiency for the alternative portfolios we create.

After evaluating the necessary algorithms to perform our MVO and DRO analysis of each of the five L Funds, we will model and simulate monthly returns and investor inputs to capture the difference in expected portfolio value each optimization method yields in various participant scenarios. Next, we will perform assorted statistical and sensitivity analyses to determine the significance of each simulation model and culminate our research effort with a detailed study of the practical significance of our work. After we evaluate the TSP L Funds and our L Fund portfolio alternatives for efficiency and optimality, we will be able to address the following questions:

- Which optimization method provides investors with an optimal TSP L Fund portfolio?
- What is the future value comparison of efficient L Fund portfolios based on individual investment streams and simulated monthly returns using MVO and DRO?

As part of this research effort, a comprehensive literature review will be accomplished to 1) provide a sound level of knowledge on 401(k)s and the TSP, 2) scrutinize both portfolio theories (among others) and optimization methods, and 3)

investigate the principles of investor utility and behavioral economics and their relation to both MVO and DRO. In turn, we will answer the following questions:

- How do economic behavior and investor rationality influence decisions pertaining to investing into an L Fund?
- Are the current TSP L Funds the most efficient asset allocation portfolios for participants or can an alternative set of portfolios based on either MVO or DRO provide at least equivalent returns with less risk?
- What is the present value comparison of an investment stream into the TSP L Funds and L Fund alternative portfolios?
- Which L Funds (MVO or DRO) provide the best chance for investors to achieve their retirement goals?
- Can offer design changes to TSP that may increase participation levels for the L Funds?

Methodology

Our research effort and methodology will compare the TSP L Funds through two different optimization methods: MVO and DRO. To do so, we first will gather TSP individual fund and L Fund historic returns and perform a normality test; both MVO and DRO have conflicting assumptions on whether returns must be normally distributed. In addition, we will collect the quarterly target allocations for each L Fund. Next, we will build the necessary algorithms for our MVO and DRO models, using Microsoft Excel and the *Palisades Corporation's @Risk* simulation software (@Risk, 2009), to optimize

efficient asset allocation alternatives to the five current TSP L Funds available for government participants. We will create these alternative portfolios using the same methodology as the current TSP L Funds, choosing an initial target allocation of the five individual funds (as of August 2005) and decrementing each alternative fund along an efficient frontier. After we develop these alternative portfolios, we will utilize investor inputs and by using Monte Carlo simulation of monthly returns, determine the expected future value of each TSP L Fund and L Fund alternative portfolio. Lastly, we will perform a variety of sensitivity analyses by varying our investors' inputs. Hence, this research will provide a thorough analysis of the TSP L Funds and help participants choose an efficient portfolio that maximizes expected return for a level of risk they are willing to assume. This effort will seek to create an alternate set of L Funds which provide a more efficient portfolio for TSP participants and test the FRTIB claims that the current L Funds are the ideal set of managed asset allocation portfolios available.

Scope and Limitations

The purpose of this research is to investigate whether the current TSP L Funds are the most efficient investment portfolios available, based on a specific time horizon, to TSP participants. To aid current and future TSP participants in selecting an ideal and efficient asset allocation for meeting their personal retirement goals, the results of this research and simulations must be:

1) Widely available to TSP investors, both civilian employees and military members

2) Easy to understand by both savvy investors and those without extensive financial management knowledge, and
3) Streamlined and dynamic, i.e., capable of accepting changes of investor's inputs such as updates to risk preference, investment contributions, time to retirement, etc.

Consequently, participants must not use this tool for a one-time decision analysis, but rather continually as their goals and preferences change. This research will only pertain to portfolio optimization within the realm of the TSP. Although the theories used and discussed are applicable to many 401(k) plans and other investment vehicles, the TSP is available to only federal civilian employees and military members; it offers unique features that other similar private plans do not. The optimization methods we will use in this research will only take into account historic TSP returns. Therefore, we cannot extend any specific analyses (other than general concepts) to investments plans outside the TSP with different returns and professional management. Lastly, the TSP allows participants to invest in both the L Funds as well as individual funds as they see fit to meet their retirement needs. In order to simplify this effort, we will only analyze the TSP L Funds, meaning within the confines of this research, a TSP investor can only invest into one of the L Funds and may not split contributions with any of the individual funds as well.

Review of Chapters

Chapter 2 consists of a literature review, outlining employee retirement plans, notably private sector 401(k) plans, and specifically, the TSP. The chapter will outline the basic rules and regulations of the TSP as well as the types of individual and L funds participants may select. Chapter 2 will also examine various portfolio optimization theories and aspects of behavioral economics as well as the definition of risk. We will aim to discuss and analyze different investment strategies, thereby establishing an intellectual baseline for the research and methods developed in this paper. Chapter 3 covers the tested methodologies for this research. Specifically, Chapter 3 will seek to develop a detailed analysis of both MVO and DRO with regard to the TSP L Funds as well as develop an alternative set of L Fund portfolios that participants may choose in order to reach their desired retirement goals. Chapter 4 will document results and evaluate participants' choices in selecting an optimal asset allocation portfolio. Lastly, Chapter 5 will summarize the results of the research and examine the TSP L Funds and L Fund alternatives for future investors as well as the applicability and limitations for their implementation and use on a US Government-wide basis.

II. Literature Review

Employee Retirement Plans

In 1974, Congress signed the Employee Retirement Income Security Act (ERISA) into law, which set the minimum standards for most voluntarily established pension plans in private industry, and provided the necessary protection for employees to participate in these plans (United States DoL, 2010). ERISA covered two types of employee pension plans: defined benefit and defined contribution plans.

Defined Benefit Plans

According to the US Department of Labor (DoL), defined benefit plans "promise [employees] a specified monthly benefit at retirement" (2010). Typically, this amount is based on a calculation of factors such as salary and years of service. All contributions for a defined benefit plan are employer-sourced, meaning employees do not contribute. This type of plan provides security in the sense of ensuring a predictable retirement benefit for an employee, but is costly to employers and difficult to manage. Today, the Internal Revenue Service (IRS) states there are roughly 38,000 defined benefit plans for employees nationwide, down from 114,000 in 1985 (Choosing a Retirement Plan, 2009).

Defined Contribution Plans

Unlike a defined benefit plan, a defined contribution plan does not specify a certain amount of benefits at retirement. According to a report issued by the US Government Accountability Office (GAO) on private pensions, "defined contribution plans provide greater portability of benefits, but shift the responsibility of saving for retirement from employers to employees" (2007:1). Employers and/or employees contribute to the employee's plan and employers invest these contributions on behalf of the employee. The IRS and the charter of the specific defined contribution plan itself limit the contribution amounts. The value of the account for an individual is the total amount of contributions made by employee and employer, plus any investment gains or losses. Examples of defined contributions plans include 401(k) plans, 403(b) plans, and Employee Stock Ownership Plans.

The most popular of defined contributions plans for employees and employers alike is the 401(k) plan. The Revenue Act of 1978 established these plans under Internal Revenue Code (IRC) Section 401(k) (EBRI, 2005:1). The IRS defines a 401(k) plan as "a type of tax-qualified deferred compensation plan in which an employee can elect to have the employer contribute a portion of his or her cash wages to the plan on a pretax basis" (Topic 424 – 401(k) Plan, 2009). Employee contributions, or "elective deferrals," are not subject to federal or state income tax but do count as wages earned. Thus, these contributions are subject to Social Security, Medicare, and federal unemployment taxes. Employees may choose elective deferrals to be invested into stocks, bonds, cash-equivalents, or a portfolio of these, depending on the available 401(k) program from their employer (EBRI, 2005:1).

Any earnings are tax deferred as well, subject to income taxes only at time of withdrawals. Withdrawals from any 401(k) plan may be made without penalty beginning at age 59 ½. Early withdrawals (when used as part of gross income) are subject to an additional 10% tax penalty unless the IRS grants a waiver for exception.

Section 402(g) of the IRC places limits on the dollar contribution amounts employees can make toward their 401(k) plans. For 2010, the IRS standard elective deferral contribution limit for employee contributions is $16,500. Based on the specific 401(k) charters submitted to the IRS, employers may choose to contribute or "match" all or a percentage of employee contributions. Employer contributions in 2010 are also limited under IRC, Section 414(c) to $49,000 (IRS – 401(k) Resource Guide, 2009). The IRS extends another separate benefit to those employees over the age of 50 through catch-up contributions. In 2010, IRC, Section 414(v) limits catch-up contributions to $5,500.

The Thrift Savings Plan

General Overview

The Thrift Savings Plan (TSP) is a "defined contribution retirement plan offered to employees of the US Government, both civilian and military members" (FRTIB – Summary, 2008:1). It is similar to plans that private-industry employers offer their employees under the IRS defined 401(k) plan. Congress authorized the TSP in the Federal Employees' Retirement Systems Act of 1986 and bestowed the management responsibility to the Federal Retirement Thrift Investment Board (FRTIB), an

independent Government agency whose primary mission is to operate the TSP solely in the interests of investors and their designated beneficiaries (Clifton Gunderson, 2009:3). As of April 2009, the FRITB reported that the TSP had over 4 million active participants (encompassing approximately 85% of government employees and 37% of active duty military) with an estimated balance of nearly $198 billion, making it one of the largest defined contribution plans in the United States (Investment Company Institute, 2008:1).

Federal civilian employees and military members are able to contribute to their individual TSP retirement plan through three means: employee contributions (standard or catch-up), agency automatic contributions, and/or matching contributions. As with private-industry 401(k) plans, TSP participants can make standard employee contributions from basic payroll deductions (any dollar amount or whole percentage of pay not to exceed the IRS maximum contribution limit). Participants who are at least 50 years old can make catch-up contributions in addition to their standard employee contributions.

Although both civilian employees under the Federal Employees' Retirement System (FERS) and Civil Service Retirement System (CSRS) are able to make standard employee contributions, employees under FERS are able to take advantage of both agency automatic and matching contributions. Federal civilian employees hired after January 1, 1984, are defined as FERS employees; CSRS employees are those hired before that date and who chose not to convert to the new FERS retirement system (TSP – Features for Civilians, 2009). Agencies will automatically contribute 1% of any FERS employee's basic pay each pay period regardless if standard employee contributes. Furthermore, FERS employees are entitled to matching contributions on the next 4% of

pay they contribute in a given pay period (FRTIB – Summary, 2008:4). The first 3% of employee contributions will be matched by the agency dollar-for-dollar and the last 1% matched at 50 cents on the dollar. Agencies will not match any FERS employee contributions above 5% nor match any contributions made by CSRS employees.

Military members who participate in the TSP through standard payroll contributions are not able to receive agency automatic or matching contributions but can contribute up to 100% of any incentive, special or bonus pay (FRTIB – Summary, 2008:2). Contribution limitations and rules for the TSP mirror those for any private-employer sponsored 401(k) plans.

TSP Investing Options for Federal Employees

There are two approaches to investing into the TSP. Federal civilian employees and military members may select to invest into any of the following individual funds: Government Securities Investment (G) Fund, Fixed Income Index Investment (F) Fund, Common Stock Index Investment (C) Fund, Small Capitalization Stock Index (S) Fund, or the International Stock Index Investment (I) Fund. In the second approach, participants may also select to contribute one of the five Lifecycle, or L, Funds. Designed by the FRTIB and Mercer Investment Consulting, Inc, the L Funds are professionally managed asset allocation portfolios comprised of the five individual TSP funds and tailored to a specific time horizon (FRTIB – Thrift Savings Plan, 2010: 1-2).

Of the five individual funds, the TSP classifies both the G and F Funds as fixed income funds whereas the C, S, and I funds are designated as stock funds. BlackRock

Institutional Trust Company manages all individual funds except for the G Fund through contract; the FRTIB manages the G Fund. The Blackrock funds to which the F, C, S, and I funds are invested are index funds (passively managed) whose portfolios are based on a specific market index composition. The goal of these funds is to match the indices each tracks, less any administrative and/or management expenses from Blackrock, instead of attempting to outperform the said indices (TSP – Features for Uniformed Services, 2010)

The G Fund invests in short-term US Treasury securities, but seeks interest rates similar to those of long-term Government notes and bonds, without any risk of loss of principal or volatility. The objective of the G Fund is to return rates higher than inflation, without added default or market risk, and with guaranteed payment of principal and interest by the U.S. Government. Thus, there is no "credit risk" (FRTIB – Thrift Savings Plan, 2010:3). The annualized return (as of December 31, 2008) of the G Fund since inception on April 1, 1987 is 6.30%.

The F Fund seeks to earn an interest rate above those from similar money market funds over the long-term. The F Fund looks to match the performance of the Barclays Capital U.S. Aggregate Index (previously known as the Lehman Brothers U.S. Aggregate Index), which represents the U.S. bond market (FRTIB – Thrift Savings Plan, 2010:5. The annualized return (as of December 31, 2008) of the F Fund since inception on January 29, 1988 is 7.16%.

The C Fund looks to match the Standard and Poor's (S&P) 500 Index performance, earning long-term returns from a diversified portfolio of stocks of large and medium-sized U.S. firms. Blackrock invests the C Fund into the Blackrock Equity Index

Fund which benchmarks against the S&P 500. The annualized return (as of December 31, 2008) of the C Fund since inception on January 29, 1988 is 8.54%.

Unlike the C Fund, the S Fund looks to earn long-term returns by investing in a diversified portfolio of stocks of small and medium-sized U.S. companies. The fund tracks the Dow Jones U.S. Completion Total Stock Market Index, which is a market index made up of U.S. stocks not included in the S&P 500 Index. The annualized return (as of December 31, 2008) of the S Fund since inception on May 1, 2001 is 1.48%.

According to the FRTIB, "the I Fund seeks to earn long-term returns by investing in the stocks of companies in developed countries outside the United States" (FRTIB – Thrift Savings Plan, 2010: 11-12). The I Fund benchmarks against the Morgan Stanley Capital International EAFE (Europe, Australasia, and Far East) Index. The annualized return (as of December 31, 2008) of the I Fund since inception on May 1, 2001 is 1.05%.

The FRTIB introduced the L Funds on August 1, 2005, for participants who may not have the time or experience to manage a portfolio of individual funds for their retirement. The L Funds diversify participant accounts among the G, F, C, S, and I Funds, using professionally determined investment allocations tailored to different time horizons. This is commonly referred to as an asset allocation approach. According to the FRTIB, the L Funds are the most efficient and optimal asset allocation portfolios at each level of risk, providing the highest expected return (FRTIB – Thrift Savings Plan, 2010: 1-2). The FRTIB recommends that investors put their entire TSP account into the L Fund that corresponds with their expected retirement date. Each L Fund rebalances each business day to its target allocation and adjusts quarterly, "rolling" down an efficient frontier to a more conservative allocation as the fund moves closer to its specified time

horizon (FRTIB – Thrift Savings Plan, 2010: 1-2). Figure 1 below shows the January 2009 target allocations for each of the five L Funds.

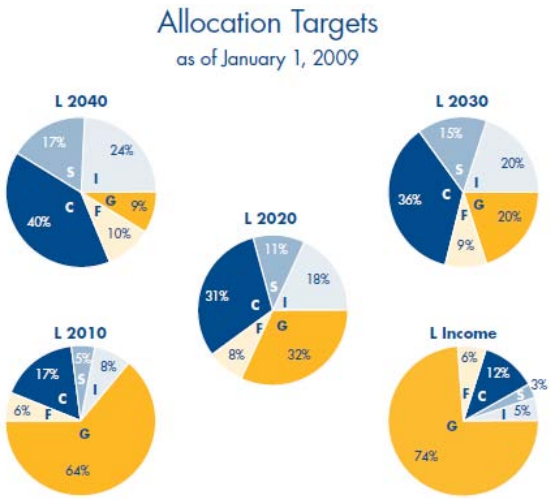

Figure 1: L Fund Target Allocations - January 2009

The five L Funds, designed for the TSP by Mercer Investment Consulting, Inc, are:

L2040 – for participants who need retirement earnings in the year 2035 or later

L2030 – for those who need earnings between 2025 and 2034

L2020 – for those who need earnings between 2015 and 2024

L2010 – for those who need earnings between now and 2014

L Income – for those who are already withdrawing their monthly payments

Thus, if a TSP participant chooses to invest in the L2040 based on an expected retirement or withdrawal date near 2040, the fund will gradually move towards the L Income target allocation each quarter as it nears the 2040 time horizon. When a fund reaches its horizon, it will become the L Income Fund and the FRTIB will create a new fund in its place (FRTIB – Thrift Savings Plan, 2010: 1-2). For example, when the L2010 fund reaches its horizon in July 2010 and "rolls" into the L Income Fund target allocation, the TSP will determine an L2050 fund to takes its place.

Portfolio Optimization Theories

Risk

The definition and use of risk is the most important component of any portfolio optimization theory. Markowitz (1952:81) defined risk through the Modern Portfolio Theory (MPT) as the variance (easily measured as the standard deviation) from the expected mean return of a portfolio. Extensions of the MPT such as the Capital Asset Pricing Model (CAPM) (Sharpe, 1964:428; Linter, 1965:14), Arbitrage Pricing Theory (APT) (Ross, 1976:342), and Blanchette's TSP investor decision tool thesis work (2004:37) used the Markowitz variance or standard deviation definition of risk. Other optimization theories such as downside risk optimization (DRO) identify the standard deviation definition of risk as being a poor proxy, likening risk as more of an emotional concern or failure to reach a financial goal (Swisher and Kasten, 2005:74). Instead of minimizing the portfolio's variance, DRO optimizes portfolios by minimizing its downside risk; the Lower Partial Moment (LPM) or Co-Lower Partial Moment (CLPM) (Harlow, 1991:30; Sing and Ong, 2000:213). Ultimately, investors may view risk in one of two ways – either stand-alone (the risk of an asset by itself) or as part of a portfolio and as either diversifiable or non-diversifiable. Markowitz (1952:79) said that "diversification cannot eliminate all variance [risk]." Therefore, all optimization theories seek to maximize efficient returns and minimizing a level of non-diversifiable, investor risk (Harlow, 1991:31; Markowitz, 1952:79; Roll and Ross, 1980:1082; Sharpe, 1964:425-427).

Markowitz and Modern Portfolio Theory

American economist Harry Markowitz aimed to create an optimal investment strategy that would seek an efficient or optimal portfolio of assets, providing a maximum expected return for an assumed level of risk (variance) by an investor (1952:79). The MPT also seeks to minimize risk given an expected level of desired return and has become the foundation of modern investing. His theory uses three variables in order to find an efficient portfolio: the expected return of a portfolio, the covariance between individual assets within the portfolio (the degree to which the assets vary together), and the variance (or standard deviation) from the mean expected return of the portfolio as an overall measure for risk. Markowitz showed via mean-variance optimization (MVO) that these three variables could create an efficient frontier set of investment portfolios, meaning a maximized return for a given level of risk assumed (or minimized risk for a given level of return). Given this frontier set, rational investors would prefer and choose a portfolio of assets lying on the efficient frontier rather a portfolio lying above (technically impossible) or below (less than optimal) (Markowitz, 1952:83-84). Figure 2 illustrates Markowitz's efficient frontier concept in a risk/return framework.

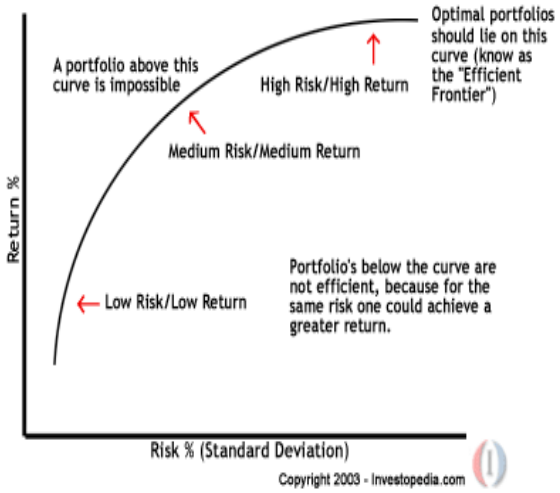

Figure 2: The Efficient Frontier (Investopedia, 2009)

Markowitz measured the expected return of a portfolio as the weighted average of the expected returns of the individual assets chosen by the investor that make up the portfolio (Markowitz, 1952:81). Markowitz defined the expected return of a portfolio as:

$$E = \sum_{i=1}^{N} X_i \mu_i \tag{2.1}$$

Where E is the expected return of the portfolio; N is the number of assets in the portfolio; X_i is the percentage of investor's portfolio allocated to asset i in the portfolio; and μ_i is the expected return of asset i in the portfolio (1952:81). To measure the portfolio's risk, the covariance (σ_{ij}) between the portfolio's assets must be computed first. Markowitz measured this covariance as:

$$\sigma_{ij} = \rho_{ij}\sigma_i\sigma_j \tag{2.2}$$

Where ρ_{ij} is the correlation between assets i and j (measure of how two assets vary up or down together); and σ_i and σ_j, are the standard deviations of assets i and j from the expected mean return (1952:80).

The portfolio's variance, V, is then measured as:

$$V = \sum_{i=1}^{N} \sum_{j=1}^{N} \sigma_{ij} X_i X_j \quad (2.3)$$

Where $\sigma_{ij,}$ is the covariance between two portfolio assets *i* and *j*, and X_i and X_j are the percentages of the investor's portfolio allocated to assets *i* and *j* (Markowitz, 1952:81).

The square root of the portfolio's variance, or the standard deviation, easily represents the level or risk of the portfolio in MPT. Markowitz (1952:80) identified variance as a common measure of return dispersion but advocated that standard deviation could be used as a measure of portfolio dispersion as well.

The Capital Asset Pricing Model: Linking MPT and the risk-free asset

An extension of Markowitz's MPT, CAPM was developed in the 1960s by Sharpe (1964) and Lintner (1965) (among others) and investigated the influence of risk on expected returns as well as individual investor preferences towards risk. This model extends MPT through two significant concepts. First, CAPM introduces the risk-free asset. Sharpe (1964:433) defined the risk-free asset as "the common pure rate of interest all investors are able to borrow or lend funds on equal terms at." In today's market, investors can associate the risk-free rate of return with three-month US Treasury-bills. Second, CAPM distinguishes between non-diversifiable portfolio risk, which should be rewarded for (systematic, or market risk) and portfolio risk that can be diversified away (unsystematic risk).

The CAPM is a blend of the Capital Market Line (CML), which is simply a linear relationship between a portfolio's risk and expected rate of return and the Markowitz

MPT efficient frontier (Sharpe, 1964:425-427). In the CAPM framework (Figure 3), the y-axis measures the expected rate of return for portfolio (having an intercept equal to the risk-free rate of return) and the x-axis measures portfolio risk.

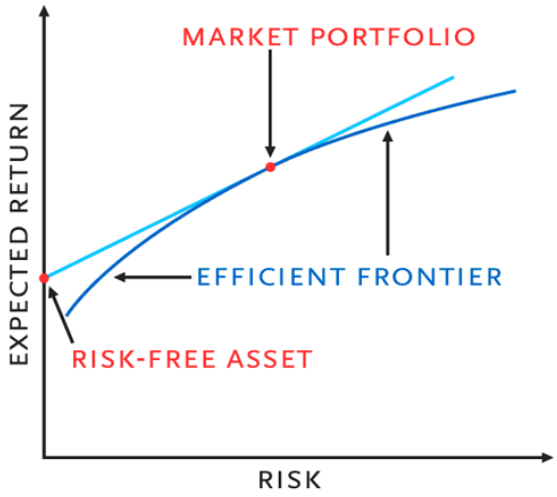

Figure 3: The CAPM Model (Schmidt, 2009)

A very risk-averse investor would invest at the risk-free asset rate of return. However, with added risk, an investor can "lend funds at the risk-free interest rate and invest the remainder in a portfolio of risky assets along their indifference, or utility, curve (Sharpe, 1964:434). This optimal portfolio will lie at the point of tangency between the CML and efficient frontier. Choosing a portfolio not at the CML and efficient frontier point of tangency would be sub-optimal, either overvalued (too much risk for required return, or below the CML) or undervalued (too much return given a certain level of risk in the portfolio, or above the CML). Under an assumption that information is free and available to all investors, the portfolio in which the investor selects will be the optimal and efficient market portfolio. From this, Sharpe assumed a "homogeneity of investor expectations" wherein investors have common expectations for risk and return (Sharpe,

1964:433). This market portfolio would also have the highest reward-to-variability or Sharpe ratio, *S*, a measure of risk-adjusted performance, defined as:

$$S = \frac{R_p - r_{RF}}{\sigma_M} \tag{2.4}$$

Where R_p is the expected return of the portfolio; r_{RF} is the return of the risk-free asset; and σ_M is the standard deviation of risky assets in the market (Sharpe, 1966:122).

The CAPM model is determined through equations for R_p, the portfolio return, as well as the portfolio standard deviation, σ_P (Sharpe, 1964:432) as:

$$R_p = \left(w_{RF} r_{RF} \right) + \left(1 - w_{RF} \right) R_M \tag{2.5}$$

$$\sigma_P = \left(1 - w_{RF} \right) \sigma_M \tag{2.6}$$

Where w_{RF} is the weight of the risk-free asset; R_M is the market risk premium (expected return of risky assets less the risk-free rate); and σ_M is the market's standard deviation.

According to Linter (1965:18), a "crucial premise" of CAPM is an investor's risk aversion, or the "preference for expected return and the preference against return variance." The beta coefficient, which measures the amount of risk that an individual asset contributes to the CAPM market portfolio, can be used as a proxy for a level of risk aversion. The market beta of an individual asset is then the "sensitivity measure of any asset's return to the variation in the market return" (Fama and French, 2004:28). The equation for an asset's beta coefficient (b_i) and an overall portfolio beta (b_p) are as follows:

$$b_i = \frac{COV_{iM}}{\sigma_M^2} \tag{2.7}$$

$$b_p = \sum_{i=1}^{n} w_i b_i \tag{2.8}$$

Where COV_{iM} is the covariance (the degree to which the asset and market vary together) between the asset and the market; σ^2_M is the market standard deviation squared; and w_i is the weight of an individual asset in the portfolio. An average risk stock would carry a beta coefficient equal to 1.0 (Brigham and Ehrhardt, 2008:220). Assets with relatively higher (lower) beta coefficients will add (subtract) risk to or from a portfolio. Thus, the riskier the asset ($b_i > 1.0$), the greater the required returns for investors. Less risky assets ($b_i < 1.0$) will require less return on behalf of investors.

Some critics do argue that CAPM has its limitations. Perold (2004:18) describes a limitation of "sub-optimal diversification" and Fama and French (2004:25) argue that "unfortunately, the empirical record of the [CAPM] model is poor – poor enough to invalidate the way it is used in applications." Two areas where most critics concentrate the CAPM limitations on are the assumptions that all investors will be able to borrow and lend on equal terms and that investors are assumed to have"homogeneity" of expectations in the market (Sharpe, 1964:433; Linter, 1965:14; Fama and French, 2004:29-30). The underpinning of the unlimited borrowing and lending assumption is the known and guaranteed risk-free rate of return (Fama and French, 2004:29). In the TSP, the G Fund is the closest investment to a risk-free asset, but TSP investors are unable to borrow at the G Fund rate of return. Second, the CAPM model assumes homogeneity of investor expectations such as expected value or standard deviation on various investments (Sharpe, 1964:434; Linter, 1965:15). On this note, Sharpe (1964:434) explains that all investors will view their available investment alternatives the same; however, Fama and

French (2004:26) argue that this assumption of all investors and one efficient and optimal market portfolio is an "unrealistic simplification."

Arbitrage Pricing Theory: Attempt to modify CAPM for better optimization

Stephen Ross (1976) modified Sharpe's CAPM and derived the more extensive APT model for portfolio optimization. Ross argued that the CAPM was too simplistic, its assumptions too restrictive, and an optimal portfolio in equilibrium required more factors than just risk and expected return (Ross, 1976:341-342). He noted of CAPM that "the restrictiveness of the assumptions that underlie the mean variance model have, however, long been recognized, but its tractability and evident appeal…between return and risk…have ensured its popularity" (1976:342). According to APT, expected return of a portfolio does not just depend on an asset's risk or beta coefficient, but on multiple factors of economic forces such as interest rates, GNP, and even weather (Roll and Ross, 1980:1074, 1077). At the theory's foundation is the arbitrage opportunity, or the opportunity of an investor to secure a better portfolio by the sale of others (at no cost), which guarantees positive economic profits without the addition of systematic or unsystematic risk (Roll and Ross, 1980:1077-1078). To do so, APT relies on short selling in a perfectively competitive market with unlimited information.

The APT derives an Arbitrage Pricing Line, which is similar to the CML of CAPM. However, instead of risk (beta) being the only factor, numerous factors collectively create the asset's vector of betas, or factor beta (Roll and Ross, 1980:1080).

Although APT is simple in theory, actual practice of the pricing model presents some significant hurdles. Primarily, TSP investors (and the majority of "private" investors) would not be able to optimize with APT due to the non-availability of an actual arbitrage opportunity. Francis and Ibbotson (2004:463) state, "the APT's no-money-invested assumption presumes that arbitraging short sellers are able to obtain 100% of the proceeds from their short sales to finance the purchase of their long positions." No TSP investors have the prospect to sell short and take advantage of a full arbitrage opportunity.

In theory, risk would not be the only factor affecting the expected return of an asset. However, APT does not formally define which factors are relevant in creating an asset or portfolio's factor beta. These factors may differ depending on a particular investor and Roll and Ross (1980:1075) noted through factor analysis that three "priced" factors were prevalent and a fourth may exist. Brigham and Ehrhardt (2004:267) explain that while factor analysis can be used to develop APT parameters and to quantify and compare relevant factors in terms of beta, "results are not easily interpreted and do not provide significant insight into the underlying economic determinants of risk."

Moreover, the same fundamental problems of CAPM plague APT. The assumption of unlimited borrowing at the risk-free rate is not available within the TSP and as discussed by Fama and French (2004:26), the "complete agreement" of investor expectations in the market is unrealistic.

Blanchette creates a decision support tool for TSP investors based on MPT

In 2004, AFIT Master's degree student Captain Christopher Blanchette created a TSP investor tool based on MVO. Analyzing historic individual TSP fund returns, Blanchette created 13 different MVO portfolios via linear programming and using simulation of investor cash flows and monthly returns, developed a model to assist investors in choosing between TSP investment alternatives (Blanchette, 2004:34, 40).

His simulation models estimated dollar value probability distributions of investment contributions and examined achieving both downside and upside retirement goals for TSP investors (Blanchette, 2004:38). To demonstrate his TSP tool's effectiveness, he simulated inputs of four fictitious investors: an active duty captain, 14 years from retirement; an active duty lieutenant colonel, 9 months from retirement; a GS-07 civil-service member, 20 years from retirement; and a GS-12 civil-service member, 8 years from retirement. In his model, he used investor input variables such as existing TSP balance, employee contribution, and risk/return preference.

For each investor, his simulation model selected the best portfolio with the largest weight sum of probability for achievement (Blanchette, 2004:41). Based on whether the investor was more concerned with their upside or downside retirement goal (solicited as a variable in his model), Blanchette's tool was able to select one of the 13 portfolios as an optimal investment strategy for their TSP. Blanchette performed a sensitivity analysis to determine which portfolio was ideal for each investor based on different weightings for their upside or downside goals. Using a pair-wise analysis approach, he calculated indifference points for each investor among the 12 other portfolios (Blanchette, 2004:46).

Overall, his model aimed to match investor risk preference and desired retirement return using simulation and optimization techniques based on MVO. However, his analysis is not without limitations. One limitation was Blanchette's application of MVO to devise efficient portfolios for TSP investors. As Swisher and Kasten (2005:75) explain, the MVO technique is nonsensical by its use of the standard deviation definition of investor risk. The standard deviation treats risk equally above and below the expected return. Rom and Ferguson (1993:351) as well as Swisher and Kasten (2005:76) describe MVO as treating "all uncertainty the same - surprises (i.e., variability) on the upside are penalized identically to surprises on the downside" and that true risk is investor specific. Therefore, "gains" above the expected return are actually classified as portfolio risk. Furthermore, an MVO assumption for normality of returns used by Blanchette actually fails in this research, possibly related to market losses in 2008 (highlighted in Chapter 3). Blanchette's research and decision support tool for TSP investors was practical; however newer theories of portfolio optimization such as DRO have surfaced with broader criteria which better match investors' risk preferences. For instance, the DRO theory does not require an assumption for a normal distribution of returns. Lastly, due to timing, the L Funds superseded Blanchette's effort as the FRTIB introduced these asset allocation portfolios in August 2005. His model was important for participants to select a one-time optimal portfolio of the five individual funds to reach their desired goals. He did not, however, take into consideration the asset allocation approach of the L Funds which incorporate a definitive time investor time horizon.

The Post-Modern Portfolio Theory: A behavioral look at portfolio optimization

The primary distinction between the MVO and DRO theories is the definition of investor risk. All the portfolio optimization theories aim to maximize return given a level of accepted risk, but critics argue MVO creates nonsensical and misleading optimization results due to the use of standard deviation as a risk proxy (Rom and Ferguson, 1993:355; Swisher and Kasten, 2005:75). A measure such as standard deviation assumes the same risk measurement among all investors. Harlow (1991:28) notes the MVO risk definition as ambiguous, which differs for individual investors based on their level of risk aversion. Many argue DRO is superior to MVO, alleviating the shortcomings of Markowitz's theory and the standard deviation definition of risk (Harlow, 1991:30; Swisher and Kasten, 2005:75; Sing and Ong, 2000:213). Risk is an emotional concern and Markowitz and the MVO theory fails to recognize an investor's attitude toward risk aversion (Sing and Ong, 2000:213). Investors who are experiencing upside gains in their portfolios would not define those gains as risk; however, MVO theory classifies those gains as risk and as a part the variance from the mean portfolio return. The DRO theory includes the human perceptions of risk such that the fear of loss is exponential, risk is asymmetrical (feelings about gains do not equal feelings about losses), and that risk is investor-specific (Harlow, 1991:28-30).

Whereas scholars such as Linter, Markowitz, Ross, and Sharpe used the standard deviation of expected return as the risk definition, proponents of DRO (Harlow, 1991:28; Swisher and Kasten, 2005:75) view risk not as volatility but as an asymmetrical measure focused on those returns below a specific target. Sing and Ong (2000:213), highlighting a drawback of MVO when asset returns are skewed, cite that Markowitz acknowledged

the inefficiencies in his theory and that "a semi-variance measure of asset risk that focuses only on the risks below a target rate of return, [as] an intuitively more appealing alternative." This target rate of return is known as the minimal acceptable return, or MAR, for an individual investor. The MAR (which is a different parameter than the expected mean), based on the personal risk preference for an individual investor, is critical in determining an investor's optimal portfolio (Jacobsen, 2009:1). Swisher and Kasten (2005:78) note, "since the mean and the MAR are not the same number, the downside risk (outcomes below the MAR) cannot be symmetrical to the upside (returns above the MAR)." Behavioral economic theory suggests that investors are more concerned with the prospect of losing their investments than the prospect of making money and require a certain MAR in order to invest (Jacobsen, 2009:2).

The foundation of DRO is the definition of investor risk, or more specifically, the perception of how humans perceive risk in the investing context. Investors typically weigh losses more heavily than gains in a portfolio and will often worry about making a minimal return in order to stay in the market (Rom, 1993:351). Thus, *optimization against downside risk is a more appropriate tool than optimization against a symmetrical variance that weights gains and losses equally*. Downside risk optimization minimizes the probability of an optimal portfolio falling below the investor's MAR, referring to risk as the "Lower Partial Moment," or LPM, since the optimization uses the left tail of the return distribution (Harlow, 1991:30). The formula to minimize the LPM and the probability of an optimal portfolio's returns falling below the MAR is as follows:

Select x_i to minimize: $LPM_n(\tau, x_i)$

$$= \frac{1}{T-1}\sum_{t=1}^{T} Max\left[0, \left(\tau - \sum_{t=1}^{N} x_{it} R_{it}\right)^n\right] \tag{2.9}$$

Subject to $n = 1$ *or* 2

$$C_1(x_1) = \sum_{i=1}^{N} x_i \bar{R}_i - R_p \text{ and } C_2(x_i) = \sum_{i=1}^{N} x_i - 1$$

$$x_i \geq 0, i = 1, 2, ..., N.$$

Where τ is the investor target rate of return or MAR; x_i is the allocation weight of each relevant asset *i* in a specific time period, *t*; R_i is the return of relevant asset *i* in the specific time period, *t*; and *T* is the number of previous return observations (Sing and Ong, 2000:216). Harlow and Rao (1989:287,292) note that setting *n* (the order of the LPM measure which determines the type of utility function consistent with that [downside] risk measure) equal to two defines the LPM_n measure as the "target semi-variance." Harlow (1991:36) describes the square root of the target semi-variance LPM measure as the target semi-deviation, a fair and analogous risk comparison to the MVO standard deviation [variance] measure.

Equation 2.10 takes into consideration of the covariance between assets *i* and *j* in the portfolio, computing the Co-Lower Partial Moment (CLPM). This equation minimizes the $CLPM_n$ to the expected return of the portfolio R_p. Equation 2.11 is a simple extension of Markowitz's portfolio variance equation (Equation 2.3) and replaces the covariance, σ_{ij}, between assets *i* and *j* with the CLPM from Equation 2.10.

Minimize: $GCLPM_n(\tau, R_i, R_j)$

$$= \frac{1}{T-1}\sum_{t=1}^{T} [Max(0, (\tau - R_{it}))]^{n-1}(\tau - R_{jt}) \tag{2.10}$$

$$G(x) = \sum_{i=1}^{N} \sum_{j=1}^{N} x_i x_j CLPM_n\left(\tau, x_i, x_j\right) \tag{2.11}$$

$$Subject\ to\ n = 1\ or\ 2$$

$$C_1(x_1) = \sum_{i=1}^{N} x_i \overline{R_i} - R_p \text{ and } C_2(x_i) = \sum_{i=1}^{N} x_i - 1$$

$$x_i \geq 0, i = 1, 2, ..., N.$$

The DRO theory differs from MVO in that is creates a theoretical infinite number of unique efficient frontiers for each individual investor's MAR (Rom, 1993:351). According to Rom and Ferguson, in MPT [and MVO] "the investor's goals are never explicitly considered" and any volatility above the expected return would equate to risk. Rom and Ferguson add of the PMPT and DRO that any volatility below the investor's MAR is risk; any returns above the MAR do cause "uncertainty," of which he notes is "nothing more than *riskless* opportunity for unexpectedly high returns" (1993:351).

Some have noted that portfolios optimized via DRO provide more robust and efficient results that those optimized with MVO, and that DRO is more consistent to how individuals perceive risk (Harlow and Rao, 1989:285; Harlow, 1991:29; Sing and Ong, 2001:221; Swisher and Kasten, 2005:76). Notably, DRO significantly loosens the assumptions that MVO and related theories (CAPM, APT) follow and aims more at capturing the human aspects of investor risk. Investors do not weigh portfolio gains and losses the same. An assumption of DRO is that not all investors will treat uncertainty or variability about the expected return differently (Rom and Ferguson, 1993:351). Due to increased computing power and advances in behavioral economic theory, DRO can take advantage of minimizing downside risk and asymmetrical variance to create efficient portfolios. The theory can provide analysts with the flexibility and accuracy for

constructing efficient portfolios that were once unavailable under the traditional Markowitz mean-variance methodology (Rom and Ferguson, 1993:354). Downside risk optimization finds efficient portfolios of which classic MVO would deem inefficient. Overall, DRO is a better gauge of an investor's unique risk preference and MAR (Jacobsen, 2009:3-4; Swisher and Kasten, 2005:74; Sing and Ong, 2001:214).

Investor Utility Maximization

Ideally, an investor should aim to maximize utility based on a risk/return decision strategy for a given portfolio. As Francis and Ibbotson (2002:422) describe, utility theory assumes that every rational investor will desire to maximize utility or "happiness" based on a set of decisions as well as choose an investment strategy and portfolio which provides maximum utility. Economic theory assumes that an investor's utility will increase (to some point) with increased wealth, which allows for more consumption of desired goods (Francis and Ibbotson, 2002:422). The utility function, which consists of all the choice sets for an investor, assigns values and represents a certain level of utility. Hence, an investor will be indifferent of utility at any point along a particular utility function. The higher the utility function slope in a risk/return framework, the higher the investor utility. Utility function slopes vary depending on the risk preference of the investor. A positive slope of an utility function shows that a rational investor requires a higher return in order to accept more risk and remain at the same level of utility (Fabozzi and others, 2002:43). Francis and Ibbotson (2002:422) state that rational investors will be averse to risk if they attain less utility from added risk. Modern Portfolio Theory and

related optimization theories as well as PMPT maximize a rational investor's utility function when the investor selects an efficient portfolio. A general utility function equation represents the way rational investors maximize their utility (Francis and Ibbotson, 2002:423) as:

Maximize:

$$E\left[U\left(r\right)\right] = F\left[E\left(r\right), \sigma\right] \tag{2.12}$$

From this equation, investors will maximize their level of utility or happiness by focusing on their portfolio's expected return and risk. From a PMPT standpoint, utility theory slightly changes to reflect human emotion towards risk. Swisher and Kasten (2005:76-78) point out that DRO captures the investor's risk aversion and utility theory in three ways. First, investors fear loss exponentially; anxiety over losses will alter the utility curve slope to a much steeper curve. Second, marginal utility leaks as investor's gain in the market. An investor's utility for high returns is not overwhelmingly better than for good returns. Furthermore, investor utility actually increases at a decreasing rate when investors earn increasing gains. Third, there is a "jump discontinuity" in an investor's utility curve meaning there is a sudden increase in anxiety when losses in a portfolio increase above a certain amount. Swisher and Kasten (2005:78) state "the investor's utility for the returns 'jumps' downward when the return is even the smallest fraction below an [their] MAR."

Behavioral Economics: A blend of psychology and economics

In recent years, a hybrid of psychology and economics has surfaced, blending aspects of human behavior with the traditional science of economics. Lambert (2006:50)

simply describes behavioral economics as the study of how real people actually make economic choices. Instead of the traditional economic assumption that all investors are rational, behavioral economics proposes that investors act irrationally, are persuaded by emotion, and are susceptible to shortsighted decisions in the marketplace. Ariely (2008:240) has suggested that humans are predictably irrational and prone to poor decisions in their immediate environment. Investors will often make the same mistake repeatedly but classical economic market forces will push the investor back to making the correct decision. The DRO framework recognizes that MVO ignores an investor's risk aversion (Sing and Ong, 2000:213) and that the PMPT "provides fertile ground to integrate behavioral finance into portfolio theory" (Swisher and Kasten, 2005:83).

Thaler and Sustein (2008:8) argue that humans (investors) are not able to make good, rational choices and that "nudges," or factors that can alter human behavior, can help improve decision-making. In addition, they believe "choice architects" can design systems that provide particular default options that can help irrational investors select choices, making them better off (2008:83). An example of this would automatic enrollment (opt-out decision) into the TSP upon entering the civilian service or military. If a choice architect designed this option as the default, the inertia to remain enrolled would reinforce high participation levels. Investors would save and invest money towards future retirement instead of the irrational decision to spend now and save later. However, the TSP remains a self-enrollment (opt-in) program. Even though active TSP participation of federal civilian employees is at 85%, only 37% of active duty military members actively participate by contributing to the fund. A better-designed choice architecture (i.e. opt-out approach) could help improve participation.

If one assumes the very plausible concept of investor irrationality, the benefits of employing choice architecture techniques become readily apparent. Concerning 401(k)s, Lawrence Summers, former U.S. Treasury Secretary, said of defaults in a choice architecture system, "in classical economics, it doesn't matter. But large amounts of empirical evidence shows that defaults do matter, that people are inertial, and whatever the baseline settings are, they tend to persist" (Lambert, 2006:55).

Behavioral economics is an interesting theory that both illuminates and debunks the common, and simplifying, assumptions of MPT/MVO and its related successor theories. Incorporating system design techniques and understanding human emotion can alter investment decision-making, providing a better foundation to create alternative portfolio choices or options. David Lambert (2006:53), a behavioral economist at Harvard University, described the power of choice architecture and its interaction with human irrationality and said, "There's a fundamental tension…between seizing available rewards in the present, and being patient for rewards in the future. It's radically important. People very robustly want instant gratification right now, and want to be patient in the future."

III. Methodology

Introduction

This chapter will apply the optimization methods described in Chapter 2, analyzing and comparing the efficiency of the Thrift Savings Plan (TSP) Lifecycle (L) Funds through mean-variance optimization (MVO) and downside risk optimization (DRO) via the Lower Partial Moment (LPM) and Co-Lower Partial Moment (CLPM) frameworks. Chapter 3 will begin with a description of methods. Next, we will apply the MVO and DRO models to the TSP L Funds and re-optimize the initial target allocations, seeking to find a more efficient portfolio allocation at the L Fund inception date. Then, we will conduct a variety of statistical assumption tests. Finally, after verifying the data, we will create a comparison of expected portfolio value between MVO and DRO for each of the L Funds through the simulation of monthly returns and various investment streams.

Mean-Variance and Downside Risk Optimization Models

Data Collection, Verification, and Normalization

We collected data for this research from four primary sources:

- The TSP website (for individual fund returns, L Fund returns, and L Fund quarterly target allocations)
- Wilshire website for Wilshire 4500 returns
- Morgan Stanley website for Europe, Australasia, Far East (EAFE) returns
- Federal Reserve website for 90-day Treasury Bills (T-Bill) returns

First, we collected historical monthly returns from the TSP website (TSP – Returns and Share Prices, 2009) for the G, F, and C Funds from February 1988 through December 2009. Despite the G Fund inception date of April 1, 1987, and the F and C Fund inception date of January 29, 1988, we chose to start our data collection with the February 1988 return as it represents the first full month of returns for these three individual funds.

The TSP did not introduce the S and I Funds until May 1, 2001; therefore, we used the applicable benchmark index for each fund to serve as the historic monthly return from February 1988 to April 2001. We collected historic monthly return data for the Wilshire 4500 (Wilshire Associates Incorporated, 2009) and the Morgan Stanley International EAFE (Morgan Stanley Capital International Barra Inc, 2009) indices to serve as proxies for S and I Fund returns, respectively. The S Fund tracked the Wilshire 4500 from its inception until June 7, 2004. On this date, the TSP assumed the Dow Jones Wilshire 4500 Completion Index as the new benchmark for the S Fund. As of April 1, 2009, the S Fund tracks the Dow Jones US Completion Total Stock Market (TSM) Index due to an expired agreement the Dow Jones Indices and the Wilshire 4500. According to the TSP website, the Dow Jones US Completion TSM Index is identical in form and historical returns as the Wilshire 4500 (TSP – Name Change, 2009). We highlighted this new benchmark in the S Fund section of Chapter 2. To complete our individual TSP fund historic returns data collection, we gathered monthly return data for the S and I Funds from May 2001 through December 2009 (TSP – Returns and Share Prices, 2009).

In addition to collecting individual fund returns, we compiled historic TSP L Fund monthly returns from August 2005 through December 2009 and quarterly target

allocations from August 2005 through July 2040 from the TSP.gov website (TSP – Returns and Share Prices, 2009). As previously stated in Chapter 2, the FRTIB set the quarterly target allocations for each L Fund at the August 1, 2005 inception date through July 2040, the ending month to which the L2040 Fund reaches its time horizon and becomes the L Income Fund target allocation.

We recorded monthly 90-day T-Bill returns from February 1988 through December 2009 to correspond with our individual TSP funds returns from the Federal Reserve website (2009). These returns will serve as our risk-free rate of return in all three optimization models. Historic monthly returns for the individual TSP funds and L Funds, L Fund quarterly target allocations, and 90-day T-Bill returns are located in Appendix A.

Test for Normality

An assumption of MVO is that return data of any asset are drawn from a normal distribution. However, DRO assumes the opposite of MVO; return data need not be drawn from a normal distribution as highlighted in Chapter 2. We used the Shapiro-Wilk Test for Normality to determine whether the return data are drawn from a normal distribution for both the TSP individual funds and L Funds. For our test of normality, we defined the null and alternative hypotheses as:

> H_0: the individual TSP funds and L Funds monthly return data are from a normal distribution
>
> $H_{A:}$ the individual TSP funds and L Funds monthly return data are not from a normal distribution

We show in Table 1 the results from our Shapiro-Wilk Test of Normality for all five individual funds and L Funds from inception through December 2009. At a level of significance, α, equal to 0.05, note that the all but one fund fails the test of return data being drawn from a normal distribution. The failure to pass a test of normality as well as to fail the normality assumption made by Markowitz for MVO shows that on statistical grounds, the DRO assumption of non-normal return data is more appropriate when analyzing this research's optimal portfolios.

Table 1: Shapiro-Wilk Test of Normality Results

Fund	W-stat	p-value	Fund	W-stat	p-value
G Fund	0.988	0.022	**L2040**	0.925	0.003
F Fund	0.993	0.275	**L2030**	0.924	0.002
C Fund	0.974	0.000	**L2020**	0.924	0.002
S Fund	0.967	0.000	**L2010**	0.914	0.001
I Fund	0.984	0.006	**L Income**	0.912	0.001

Optimization Model Design

We chose to use Microsoft Excel for our MVO and DRO (LPM and CLPM) framework modeling. First, we calculated the expected mean (average) return, adjusting for the risk-free rate of return, of the individual TSP funds from February 1988 through December 2004 (Harlow, 1991:33). This set of monthly returns would have been available to either the FRTIB or Mercer Investing Consulting, Inc, when the TSP L Funds were created in August 2005. Therefore, for a true comparison, our optimization models used these returns to compute the MVO, DRO (LPM) and DRO (CLPM) L Fund portfolio alternative allocations.

Next, we calculated the equivalent risk measurements in each optimization theory. To measure MVO portfolio risk, we determined the portfolio standard deviation from the square root of the portfolio's variance. The MVO portfolio variance measurement is:

$$V = \sum_{i=1}^{N} \sum_{j=1}^{N} \sigma_{ij} X_i X_j \tag{2.3}$$

To measure risk in our DRO (LPM) framework model, we applied the following equation to calculate the LPM. In both Equations 2.9 and 2.10 below, we set the investor's minimal acceptable return (MAR, or τ) equal to 2.7%, which is the current 30-year real interest rate calculated by Office of Management and Budget (OMB, 2009). We define this rate as inflation; therefore, an assumption of our DRO models is that the investor desired to at least beat inflation in their optimal portfolio.

Select x_i to minimize: $LPM_n(\tau; x_i)$

$$= \frac{1}{T-1} \sum_{t=1}^{T} Max\left[0, \left(\tau - \sum_{t=1}^{N} x_{it} R_{it}\right)^n\right] \tag{2.9}$$

For our DRO (CLPM) model, we used the following equation to measure the CLPM risk, taking into account the covariance between the individual TSP funds:

Minimize: $GCLPM_n(\tau, R_i, R_j)$

$$= \frac{1}{T-1} \sum_{t=1}^{T} [Max(0, (\tau - R_{it}))]^{n-1} (\tau - R_{jt}) \tag{2.10}$$

Minimize:

$$G(x) = \sum_{i=1}^{N} \sum_{j=1}^{N} x_i x_j CLPM_n(\tau, x_i, x_i) \tag{2.11}$$

We applied the Microsoft Excel Solver Add-in tool to solve and create optimal portfolios in each model based on each risk minimization function. We set two

constraints in all three models in that the sum of the individual fund allocations must equal one and that the desired return would equal to the expected monthly portfolio return of the TSP L Funds at inception. This would ensure the solver function invested 100% of the allocation for each of the five individual funds into the optimized portfolio and met each TSP L Fund return for its specific time horizon.

To solve for the optimal portfolios in each framework, we first inputted the TSP L Funds August 2005 target allocations into the MVO, DRO (LPM), and DRO (CLPM) model solver functions and recorded the expected monthly portfolio return (using the risk-free adjusted historic individual fund returns) for each L Fund based on Equation 2.1.

$$E = \sum_{i=1}^{N} X_i \mu_i \tag{2.1}$$

Next, we used the Solver Add-in to optimize an L Fund portfolio alternative in each framework, meeting the recorded expected monthly portfolio return (for each TSP L Fund at inception) and minimizing the specific risk measurement using Equations 2.3, 2.9, 2.10, and 2.11. In order to compare this research's optimal L Fund alternative allocations to the initial L Fund target allocations, we rounded to the nearest whole integer (meeting the 100% portfolio invested constraint) for the newly optimized L Fund alternatives from each framework. Lastly, we recorded the new expected monthly risk measurement (standard deviation, LPM, or CLPM) and corresponding expected monthly portfolio return for each of the newly optimized L Fund alternatives at their whole integer portfolio allocation. Table 2 below shows the risk/return comparison, as of August 2005, of the TSP L Fund portfolios at inception as well as our L Fund alternatives (labeled

'Thesis') in the three optimization frameworks. Any difference in the level of expected monthly portfolio return between the TSP L Funds and the L Fund alternatives optimized in each framework is due to rounding the latter's allocation to the nearest whole percent.

Table 2: Risk/Return of Optimized TSP L Funds in MVO and DRO

MVO Framework					
TSP	**Return**	**Risk**	**Thesis**	**Return**	**Risk**
L2040	0.50%	3.43%	L2040	0.49%	2.45%
L2030	0.46%	3.03%	L2030	0.46%	2.16%
L2020	0.42%	2.61%	L2020	0.42%	1.83%
L2010	0.36%	2.01%	L2010	0.35%	1.36%
L Income	0.25%	0.81%	L Income	0.25%	0.63%
DRO (LPM Framework)					
TSP	**Return**	**Risk**	**Thesis**	**Return**	**Risk**
L2040	0.50%	3.50%	L2040	0.49%	2.54%
L2030	0.46%	3.09%	L2030	0.46%	2.25%
L2020	0.42%	2.68%	L2020	0.42%	1.92%
L2010	0.36%	2.07%	L2010	0.35%	1.46%
L Income	0.25%	0.97%	L Income	0.25%	0.74%
DRO (CLPM) Framework					
TSP	**Return**	**Risk**	**Thesis**	**Return**	**Risk**
L2040	0.50%	2.54%	L2040	0.49%	1.67%
L2030	0.46%	2.23%	L2030	0.46%	1.46%
L2020	0.42%	1.91%	L2020	0.42%	1.18%
L2010	0.36%	1.45%	L2010	0.35%	0.84%
L Income	0.25%	0.53%	L Income	0.25%	0.32%

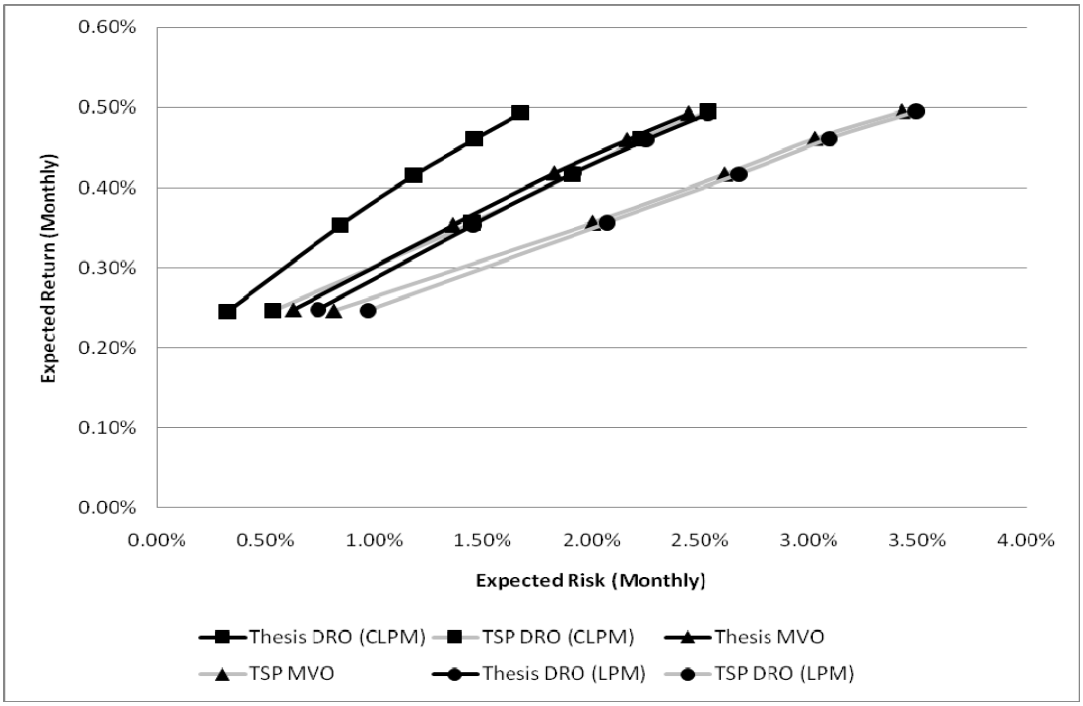

Figure 4: Efficient Frontiers of TSP L Funds and L Fund Alternatives

Figure 4 displays the corresponding efficient frontiers of each TSP L Fund and our research's L Fund alternatives ('Thesis') in all three optimization frameworks. As shown, the DRO (CLPM) model provides the most efficient frontier. The L Fund portfolios along this efficient frontier provide the same level of expected monthly portfolio return with less expected monthly portfolio risk assumed by the investor than the MVO or DRO (LPM) models. *Therefore, we chose the DRO (CLPM) theory and L Fund portfolios to serve as the alternative set of L Fund portfolios for our simulation models and research analysis.* Table 3 shows the resulting initial target allocation comparison of the five TSP L Funds as well as our five DRO (CLPM) L Funds from the risk/return comparison in Table 2. These allocations are as of the TSP L Fund August 1, 2005 inception date. The complete listing of quarterly target allocations for both the L Funds and L Fund alternatives are located in Appendix B.

Table 3: TSP and DRO L Fund Target Allocations at Inception

TSP L Funds					
	G Fund	**F Fund**	**C Fund**	**S Fund**	**I Fund**
L2040	5.00%	10.00%	42.00%	18.00%	25.00%
L2030	16.00%	9.00%	38.00%	16.00%	21.00%
L2020	27.00%	8.00%	34.00%	12.00%	19.00%
L2010	43.00%	7.00%	27.00%	8.00%	15.00%
L Income	74.00%	6.00%	12.00%	3.00%	5.00%
DRO (CLPM) L Funds					
	G Fund	**F Fund**	**C Fund**	**S Fund**	**I Fund**
L2040	0.00%	43.00%	57.00%	0.00%	0.00%
L2030	0.00%	51.00%	49.00%	0.00%	0.00%
L2020	0.00%	62.00%	38.00%	0.00%	0.00%
L2010	1.00%	76.00%	22.00%	1.00%	0.00%
L Income	56.00%	34.00%	9.00%	1.00%	0.00%

Simulation Model Design

Using TSP and DRO (CLPM) L Fund initial target allocations from Table 3, we created a simulation model to calculate the expected portfolio value, annual percentage yield (APY), and the probability of reaching a participant's desired level of TSP retirement investment income in each portfolio. Participant inputs to the simulation model include:

- Current age (years)
- Year entered federal service or military (year)
- Time remaining in government career (years)
- Expected retirement or TSP withdrawal date (years)
- Initial TSP account balance (dollars, as of January 2010)
- Expected monthly contribution amounts (dollars, including any automatic agency and matching contributions, starting January 2010)
- Expected annual increase in monthly contributions (%)
- Desired TSP balance or retirement goal ($)

We used the *Palisades Corporation @Risk* simulation software for our models and calculated the expected portfolio value, APY, and probability of reaching different levels of retirement income from January 2010 to the expected full retirement age and/or when the participants would expect to begin TSP withdrawals. Although the model does not limit the annual contribution amounts, the models must consider the IRS 2010 contribution limits (to include any bonuses) of $16,500 and $22,000 (with catch-up contributions, for participants 50 years of age or older). These limits, according to the IRS, will remain in effect at least through 2010 and will adjust according to cost of living increases after 2010 (401(k) Resource Guide, 2009). Therefore, an assumption of our models and simulations is that the 2010 IRS contribution limits served as the overall limit for participant TSP contributions. If a participant's expected annual contribution

amounts would exceed these limits, we must adjust the models accordingly to ensure each runs a proper simulation.

To simulate monthly returns for both the TSP and DRO (CLPM) L Funds, we used Monte Carlo simulation to pull from probability distributions fitted to each of the five individual TSP funds from inception through December 2009. Table 4 below lists the best-fit distribution parameters according to *@Risk* (based on a Chi-Squared Statistic) for each of the five individual TSP funds. Appendix C provides the *@Risk* best-fit distribution output.

Table 4: Individual TSP Fund Distribution Parameters

G Fund	RiskLogistic(0.00488584,0.00081928)
F Fund	RiskWeibull(5.0384,0.055023,RiskShift(-0.044813))
C Fund	RiskLogistic(0.01041,0.023138)
S Fund	RiskWeibull(7.6411,0.37078,RiskShift(-0.34004))
I Fund	RiskWeibull(6.1388,0.29605,RiskShift(-0.27015))

In order to estimate the expected portfolio value of each TSP and DRO (CLPM) L Fund in our simulation, we added each subsequent monthly contribution to the previous month's portfolio balance and calculated the weighted portfolio return for that month using Equation 2.1. Using the same TSP L Fund methodology for decrementing or "rolling" each L Fund down an efficient frontier as its time horizon shortens, we decremented our DRO (CLPM) L Funds to the DRO (CLPM) L Income from Table 3 in the same manner.

Model Hypothesis Testing for Statistical Significance

In order to statistically measure the difference between the simulation outcomes, we implemented Excel's two-tail Student t-test. This test determines whether our models' expected portfolio values for each TSP and DRO (CLPM) L Funds are likely to have come from the same two populations of expected portfolio values with the same expected portfolio mean value. For our Student's t-test of significant difference, we define the null and alternative hypothesis as:

> H_0: the difference between each L Fund and L Fund portfolio alternative expected outcome (dollars) is not statistically significant
>
> $H_{A:}$ the difference between each L Fund and L Fund portfolio alternative expected outcome (dollars) is statistically significant

Model Analysis for Practical Significance – Sensitivity Analysis

An additional portion of our research included both one-way and two-way sensitivity analyses of various participant input variables into our simulation models: e.g, initial TSP account balance, initial monthly contribution amount, and annual increase in monthly contributions. The purpose of sensitivity analysis is to determine how varying these independent variable values will influence the resulting dependent variable, or the participant's expected portfolio value at retirement. A convenient way to present this analysis is through a one-way tornado and spider graphs as well as two-way data tables.

Tornado graphs help show what input variables (holding others constant) have the greatest impact on their ideal L Fund portfolio's value whereas spider graphs show what input variable an L Fund is most sensitive to in terms of percent change. Data table analysis can help a participant see what combinations of initial TSP balance, initial

monthly contributions, and/or annual contribution increase will approximately yield in expected portfolio value at their desired time horizon. Participants can then use this information to devise appropriate investment strategies, providing them the best opportunity to meet and exceed their TSP retirement goals. In addition, new participants to the TSP can use data table analysis to decide what combinations of initial balance, monthly contribution, and annual increase in monthly contribution would yield in expected portfolio value in order to best meet their retirement goal. We create one- and two-way sensitivity analyses for the desired L Fund portfolio our simulated participants select based on their preferences and simulation outcomes.

Model Analysis of Investor MAR (τ) – Sensitivity Analysis

As we stated for our DRO (CLPM) optimization models, we set the investor's MAR value (τ) equal to an annual 2.7% (or .225% monthly). We associated this percentage (OMB 30-year real interest rate) with inflation. Thus, we assumed investors would want to achieve a minimum 2.7% return and overall desired to beat inflation in their DRO (CLPM) L Fund portfolios. The DRO (CLPM) L Fund portfolio allocations are dependent on an investor defined MAR return. Therefore, continuing our sensitivity analysis, we varied τ from zero percent to 8.1% annual (zero percent to .675% monthly) to determined how modifying the investor's τ would affect the initial target allocations of the DRO (CLPM) L Fund portfolios.

Model Validation

To validate our simulation model's finding, we compared the values of both TSP and DRO (CLPM) L Fund portfolios, given a consistent monthly investment, from August 2005 through December 2009. Using the initial target allocations of each L Fund set in addition to the historic TSP individual fund and L Fund returns, we will use Equation 2.1 to compute the portfolio value of each TSP and DRO L Fund at our simulation model January 2010 start date.

IV. Results and Analysis

Introduction

The asset allocation Lifecycle (L) Funds are available to all Thrift Savings Plan (TSP) participants. As previously stated, the Federal Retirement Thrift Investment Board (FRTIB) designed the L Funds for participants who desire to have their TSP retirement investments on "cruise control," investing their entire account into a designated L Fund and allowing their contributions and the fund to be professionally managed (TSP – Lifecycle Fund Menu, 2009). The FRTIB and Mercer Investment Consulting, Inc, formulated these asset allocation L Funds to become more conservative as each nears a specified time horizon. The TSP advises participants that this time horizon should coincide with their desired retirement date and/or when they would begin drawing on their TSP account. Using Monte Carlo simulation, the research team investigated the difference in expected portfolio value at retirement between the TSP L Fund and L Funds created through a downside-risk optimization (DRO) via a Co-Lower Partial Moment (CLPM) framework. The simulations, statistical analyses, and sensitivity analyses developed in this research are designed to assist federal civilian employees and military members in making ideal TSP L Fund investment decisions. We will assess the likelihood of meeting desired retirement goals through probability tables and create one- and two-way sensitivity analyses of various user inputs based on our simulation results. The results will provide participants with concrete analysis of which TSP L Fund or DRO

(CLPM) L Fund is best for their career and investment scenario. This chapter presents three individual TSP participant examples:

1. 22 year old military member, expecting to fully retire in 2048 (age 60)
2. 32 year old military member, expecting to fully retire in 2038 (age 60), with a $54,287 and $55,905 initial TSP balance
3. 42 year old, expecting to retire from civil service in 2030 (age 62)

These three examples, although not randomly drawn from a sample of federal civilian employees and/or military members, are used to show the applicability of our models in a variety of different scenarios and across each L Fund. Our goal was to best illustrate the differences between a simulation of monthly returns and participant inputs for the TSP and DRO (CLPM) L Funds.

For our analysis, we have assumed a 2.7% inflation rate to deflate future year (then-year or TY$) dollar amounts to current or base-year (BY10$). Thus, our results account for inflation and create an even comparison in today's purchasing power. This rate is the current Office of Management and Budget 30-year real interest rate (OMB, 2009).

Simulation Examples

22 year old military member, expecting to fully retire in 2048 (age 60)

For our first example, we selected a military member at the start of his career to compare the L Funds with the longest investment time horizon, the TSP L2040 and the

DRO (CLPM) L2040. We simulated 5,000 iterations of monthly returns and the participant inputs listed in Table 5 below.

Table 5: 22 year old L Fund Simulation Model Inputs

		Current Year	**2010**
TSP balance (January 2010)	**$3,000**	**Current Age**	**22**
Initial Monthly Contribution (January 2010)	**$500**	**Year Entered Federal Service**	**2010**
Annual % Increase	**5.0%**	**Years Remaining in Career**	**20**
		Length in Months	**240**
Goal at Full Retirement (TY$)	**$2,000,000**	**Full Retirement Age**	**60**
Goal at Full Retirement (BY10$)	**$726,697**	**Year at Full Retirement**	**2048**
		Years until Full Retirement	**38**
		Length in Months	**456**

Table 6 outlines our model's results constructed from the participant inputs above. Although the participant's ideal L Fund is the L2040 based on an expected retirement date of 2048, we chose to simulate all TSP L Funds and DRO (CLPM) L Fund to show the broad application of the model and any significant differences between the TSP and DRO (CLPM) L Funds.

Table 6: 22 year old L Fund Simulation Model Results (BY10$)

22 year old - Lifecycle (L) Fund Simulation: Goal at Retirement: $726,697 (BY10$)									
L Fund	**Portfolio Min**	**5%**	**Portfolio Mean**	**95%**	**Portfolio Max**	**% chance of reaching retirement goal**	**Portfolio Mean APY**	**Portfolio Mean Difference**	**Student's t-test p-value**
DRO L2040	$302,943	$487,620	$736,505	$1,052,850	$1,527,161	43.82%	6.18%	$39,836	0.000
TSP L2040	$276,009	$449,888	$696,669	$1,014,756	$1,487,032	35.08%	6.02%		
DRO L2030	$327,858	$454,331	$588,722	$742,789	$1,033,217	4.70%	5.55%	$11,263	0.000
TSP L2030	$324,549	$438,310	$577,459	$747,686	$971,238	5.12%	5.50%		
DRO L2020	$351,086	$435,630	$518,849	$609,519	$741,892	0.00%	5.20%	$2,298	0.040
TSP L2020	$351,406	$426,325	$516,551	$616,927	$745,373	0.00%	5.19%		
DRO L2010	$351,103	$427,070	$503,297	$586,603	$705,880	0.00%	5.12%	$994	0.330
TSP L2010	$346,105	$418,935	$502,303	$594,097	$708,597	0.00%	5.11%		
DRO L Income	$351,105	$427,036	$503,287	$586,593	$705,920	0.00%	5.12%	$993	0.330
TSP L Income	$346,072	$418,906	$502,293	$594,034	$708,569	0.00%	5.11%		

The result of this simulation shows that for the participant's expected time horizon of 2048, the DRO (CLPM) L2040 provides a greater expected portfolio value of $39,836 (BY10$), higher portfolio annual percentage yield (APY) of 16 basis points, and is the superior L Fund choice to the actual TSP L2040 and other funds. The DRO (CLPM) L2040 increasingly gains on the TSP L2040 Fund from the start of the

simulation until retirement as shown below in Figure 5. Because of this, there is a statistically significant difference in the expected mean balance at retirement between the two L2040 Funds (p-value < .05).

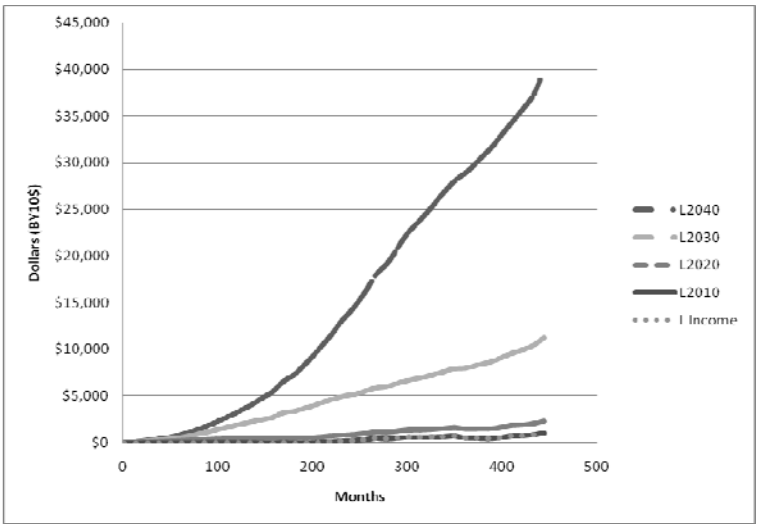

Figure 5: 22 year old L Fund Simulation Model: Cumulative Difference of DRO L Funds in Expected Portfolio Value (BY10$)

With a longer time horizon, the minimized losses in the DRO (CLPM) L2040 are never overcome by any gains in the TSP L2040. Even though the DRO (CLPM) L2040 is a more conservative allocation of the individual TSP funds, the portfolio avoids the possible losses sustained by the more volatile funds (S or I) of the TSP L2040 in this simulation.

The DRO (CLPM) L2040 also provides a better chance of meeting this participant's $2 million (TY$) desired goal at age 60 compared to the TSP L2040 by nearly 25%. The probability table for meeting his retirement goal with the DRO (CLPM) L2040 and TSP L2040 (as well as the other DRO/TSP L Fund pairs) in this simulation is found in Appendix E. This participant should select the DRO (CLPM) L2040 versus the

TSP L2040 to minimize the chance of portfolio losses in their portfolio and to have the best chance of exceeding his $2 million goal at retirement.

Consequently, we can make the same argument for the DRO (CLPM) L2030 as we did for the DRO (CLPM) L2040. If the participant felt more risk adverse and sought a portfolio that reached its time horizon quicker, the DRO (CLPM) L2030 would be the superior choice to the available TSP L2030 for expected portfolio value at retirement. The DRO (CLPM) L2030 bests the TSP L2030 by $11,263 (BY10$) and according to our Student's t-test calculation, this difference in expected portfolio value is statistically significant. The cumulative difference in BY10$ over this participant's career of the DRO (CLPM) L2030 over the TSP L2030 is also shown in Figure 5. However, the TSP L2030 Fund does hold an edge to its counterpart by improving the probability of meeting his retirement goal by almost 9%.

Even though not ideal for this participant due to his expected retirement date, the DRO (CLPM) L2020, L2010, and L Income Funds do have a higher expected portfolio value in 2048 than the TSP L2020, L2010 and L Income Funds. Although ranging from $2,298 to $993, respectively, in terms of cumulative difference between the each L Fund pair, only the difference between the two L2020 Funds is statistically significant. The difference between the L2010 and L Income pairs is similar due to the fact that the L2010 Funds "roll" into the L Income allocations in July 2010. Therefore, only seven months separate these two funds from the start of our simulation. The expected APY is nearly the same in each L Fund pair and the chance of this participant reaching his retirement goal with any of these six funds is zero percent. Figures depicting the growth of each L Fund from January 2010 to his expected time horizon are located in Appendix D.

For our one-way sensitivity analysis of this participant's simulation model, we chose to vary three model inputs:

1) Initial TSP balance by 50% (+/-),
2) Initial monthly contribution by 25% (+/-), and
3) Annual percentage increase by 50% (+/-)

We varied the above inputs for his DRO (CLPM) L2040 portfolio. Our analysis shows that in this simulation, the expected portfolio value is most sensitive to a change to his initial monthly contribution and that these contributions have the largest impact on the ending value at retirement. This makes sense due to his $3,000 initial TSP balance, which is a small percentage of the total amount he would invest into the TSP over a 20 year career. One-way tornado and spider graphs depicting the DRO (CLPM) L2040 portfolio sensitivities of these inputs are shown in Appendix F.

The two-way sensitivity analysis data tables located in Appendix G show the combinations above three simulation inputs that would approximately be needed to reach his desired $2 million (TY$) retirement goal with the DRO (CLPM) L2040 portfolio (shaded in grey). The black dot represents this simulation's expected DRO (CLPM) L2040 portfolio value. These tables are extremely useful to see what combinations of inputs can affect the expected portfolio value and the relationship they have with achieving a desired retirement goal. The simulation results and data tables show that this participant should make slight changes to ensure he meets his retirement goal, such as an increase to his initial monthly contribution. A new participant to the TSP could use this two-way data tables to see what combinations of input variables would be needed to estimate a future retirement value in the DRO (CLPM) L2040 portfolio.

32 year old, expecting to fully retire in 2038 (age 60), initial TSP balance of $54,287

In our second model, we chose to simulate a 32 year old military member with 13 years remaining in her military career and a shorter time horizon of 28 years (retiring at age 60). Her ideal L Fund based on an expected retirement date is the L2040; however, she is also considering the L2030 as her level of risk aversion has increased from the recession in 2008. She has invested $1,000 each month into the TSP L2040 since its inception in August 2005 and has amassed a balance as of January 2010 of $54,287. She wonders if the TSP L2040 is the appropriate fund needed to reach her financial goal of $1.75 million (TY$) at retirement. Overall, she would like to minimize any losses in her portfolio as much as possible. As in our first simulation, we chose to simulate her scenario for 5,000 iterations with the inputs provided in Table 7 below.

Table 7: 32 year old L Fund Simulation Model Inputs ($54,287 Initial Balance)

		Current Year	**2010**
TSP balance (January 2010)	**$54,287**	**Current Age**	**32**
Initial Monthly Contribution (January 2010)	**$1,000**	**Year Entered Federal Service**	**2000**
Annual % Increase	**2.7%**	**Years Remaining in Career**	**13**
		Length in Months	**156**
Goal at Full Retirement	**$1,750,000**	**Full Retirement Age**	**60**
Goal at Full Retirement (BY10$)	**$829,976**	**Year at Full Retirement**	**2038**
		Years until Full Retirement	**28**
		Length in Months	**336**

Table 8: 32 year old L Fund Simulation Model Results (BY10$, $54,287 Initial Balance)

32 year old - Lifecycle (L) Fund Simulation ($54,287 TSP Balance): Goal at Retirement: $829,976 (BY10$)									
L Fund	**Portfolio Min**	**5%**	**Portfolio Mean**	**95%**	**Portfolio Max**	**% chance of reaching retirement goal**	**Portfolio Mean APY**	**Portfolio Mean Difference**	**Student's t-test p-value**
DRO L2040	$351,555	$577,180	$938,282	$1,410,489	$2,375,255	58.26%	7.74%	$66,146	0.000
TSP L2040	$305,263	$519,017	$872,136	$1,337,554	$2,590,723	46.82%	7.46%		
DRO L2030	$343,098	$530,893	$732,373	$978,526	$1,416,054	18.26%	6.79%	$23,012	0.000
TSP L2030	$303,431	$497,238	$709,360	$972,856	$1,666,848	16.32%	6.67%		
DRO L2020	$421,996	$504,329	$610,985	$730,059	$887,374	0.10%	6.11%	$3,788	0.009
TSP L2020	$402,438	$490,422	$607,197	$739,078	$1,032,196	0.30%	6.08%		
DRO L2010	$397,939	$491,903	$572,268	$658,236	$762,902	0.00%	5.86%	$209	0.844
TSP L2010	$409,571	$484,134	$572,059	$666,286	$848,674	0.00%	5.86%		
DRO L Income	$397,820	$491,868	$572,182	$658,236	$762,130	0.00%	5.86%	$207	0.845
TSP L Income	$409,467	$484,335	$571,974	$666,068	$848,927	0.00%	5.86%		

It is clear in this simulation that the DRO (CLPM) L2040 is the ideal L Fund for her to select to best meet her retirement goals and protect against downside risk as shown in Table 8 above. The expected portfolio value at retirement of the DRO (CLPM) L0240 exceeds that of the TSP L2040 by $66,146 (BY10$) raises her chances of meeting her $1.75 million (TY$) retirement goal by over 24%. According to the Student's t-test p-value, this difference in expected portfolio value is statistically significant. The expected APY for her DRO (CLPM) L2040 portfolio over the 28 years until retirement is 28 basis point higher than the TSP L2040 expected APY. Figure 6 below shows the cumulative difference of the DRO (CLPM) L2040 over TSP L2040 (as well as the other L Fund pairs) in this simulation. This figure shows that the DRO (CLPM) L2040 portfolio grows more in value than the TSP L2040 as she approaches retirement.

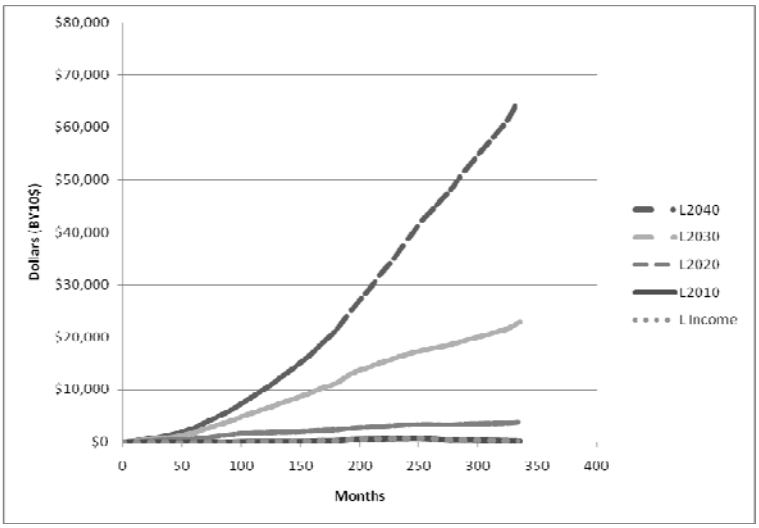

Figure 6: 32 year old L Fund Simulation Model: Cumulative Difference of DRO L Funds in Expected Portfolio Value (BY10$, $54,287 Initial Balance)

From this analysis, she should switch her current TSP investment from the TSP L2040 to the DRO (CLPM) L2040 alternative, not only meet her financial needs at retirement, but to minimize the amount of downside risk in her portfolio. Figures

depicting the growth of all ten L Fund portfolios from January 2010 until her retirement in current year dollars (BY10$) are located in Appendix D.

As mentioned, the 2008 recession and drop in the stock market have worried her about having a larger allocation of her portfolio held in the individual TSP stock funds (C, S, and I). Although the DRO (CLPM) L2040 is her ideal fund, she is considering switching her TSP balance to an L2030 Fund portfolio as it has less weight in stocks and more in the fixed income securities (G and F). If she did decide to invest into an L2030 Fund, the DRO (CLPM) L2030 would be the better choice compared to the TSP L2030. Her chances of meeting her goal are improved by almost 12% (Table 8) and the DRO (CLPM) L2030 expected portfolio value difference is $23,012 larger (BY10$, statistically significant). If she decides to hold a more conservative portfolio, the DRO (CLPM) L2030 is the superior choice to the TSP L2030 and provides better downside protection.

Lastly, despite having a less than .3% chance of meeting her goal with any of the three L2020, L2010, and L Income Fund pairs, the DRO (CLPM) alternatives do provide larger expected portfolio values at retirement than the TSP L Funds. However, only in the expected portfolio values at retirement between the L2020 Funds did we find a statistically significant difference.

The one-way sensitivity analysis in Appendices F show that the expected portfolio value of her DRO (CLPM) L2040 is impacted most by varying her initial TSP balance by +/-50%. However, this portfolio is most sensitive to altering her initial monthly contributions. As shown in her DRO (CLPM) tornado graph, her initial TSP balance (top bar) has the greatest impact on her expected portfolio value for when she

retires in 2038. The expected portfolio value is most sensitive though to unit changes in her initial monthly contributions. This is represented in the spider graph as the steepest sloped line. She can use this information along with the two-way data table located in Appendix G so create an investment strategy that can best meet her future investment goals.

The two-way data tables show the different combinations of the three input variables referred in the first simulation that this participant would need to approximately meet her financial goals at retirement. The black dot represents this simulation model's base case and her DRO (CLPM) L2040 expected portfolio value at retirement. The grey boxes represent the combinations of her model inputs that would be expected to meet her retirement goal. According to these data tables, this participant is expected to exceed her goal of $1.75 million at her retirement year in 2038 with her current initial balance, monthly contributions, and annual percentage increase in monthly contributions. She could use these data tables to weigh her options if she altered her simulation input combinations. The data tables can aid her in determining what different combinations of the three inputs in the simulation would be expected to yield in her DRO (CLPM) L2040 portfolio at retirement and are located in Appendix G.

32 year old, expecting to fully retire in 2038 (age 60), initial TSP balance of $55,905

Extending our second simulation, we chose to reassess the same 32 year old participant; however, we have altered her initial TSP balance from $54,287 to $55,905. The difference of $1,618 represents the dollar amount that this participant would have

made in the DRO (CLPM) L2040 over the TSP L2040 if the former was available at the August 1st, 2005 inception date of the actual TSP L Funds. To reach both initial balances required a $1,000 monthly contribution to the TSP L2040 and DRO (CLPM) L2040, respectively, from August 2005 through December 2009.

Changing the initial balance from $54,287 to $55,905 and maintaining the $1,000 initial monthly contribution and 2.7% annual contribution increase, we simulated monthly returns and the inputs from Table 9.

Table 9: 32 year old L Fund Simulation Model Inputs ($55,905 Initial Balance)

		Current Year	**2010**
TSP balance (January 2010)	**$55,905**	**Current Age**	**32**
Initial Allotment (January 2010)	**$1,000**	**Year Entered Federal Service**	**2000**
Annual % Increase	**2.7%**	**Years Remaining in Career**	**13**
		Length in Months	**156**
Goal at Full Retirement	**$1,750,000**	**Full Retirement Age**	**60**
Goal at Full Retirement (BY10$)	**$829,976**	**Year at Full Retirement**	**2038**
		Years until Full Retirement	**28**
		Length in Months	**336**

Table 10 below lists the combined results from this simulation's DRO (CLPM) L Funds and the results from Table 8 for the TSP L Funds. The table shows the difference in expected portfolio value that $1,618 would be expected to yield at retirement. If this participant had the ability to go back to August 2005 and select the DRO (CLPM) L2040 instead of the TSP L2040, she would have increased her expected portfolio value by $75,848 (BY10$) and her chances of exceeding her goal of $1.75 million by over 27%. The Student's t-test also reveals there is statistically significant difference between these two L2040 Fund values at retirement.

Table 10: 32 year old L Fund Simulation Model Results (BY10$, $55,905 v. $54,287 Initial Balance)

32 year old - Lifecycle (L) Fund Simulation ($55,905 v. $54,287 TSP Balance): Goal at Retirement: $829,976 (BY10$)									
L Fund	Portfolio Min	5%	Portfolio Mean	95%	Portfolio Max	% chance of reaching retirement goal	Portfolio Mean APY	Portfolio Mean Difference	Student's t-test p-value
DRO L2040 ($55,905)	$354,845	$582,684	$947,984	$1,425,766	$2,404,174	59.60%	7.76%	$75,848	0.000
TSP L2040 ($54,287)	$305,263	$519,017	$872,136	$1,337,554	$2,590,723	46.82%	7.46%		
DRO L2030 ($55,905)	$346,288	$536,054	$739,785	$988,360	$1,432,635	20.00%	6.81%	$30,425	0.000
TSP L2030 ($54,287)	$303,431	$497,238	$709,360	$972,856	$1,666,848	16.32%	6.67%		
DRO L2020 ($55,905)	$426,049	$509,065	$616,960	$737,479	$897,084	0.14%	6.12%	$9,763	0.000
TSP L2020 ($54,287)	$402,438	$490,422	$607,197	$739,078	$1,032,196	0.30%	6.08%		
DRO L2010 ($55,905)	$401,626	$496,439	$577,593	$664,399	$770,366	0.00%	5.87%	$5,534	0.000
TSP L2010 ($54,287)	$409,571	$484,134	$572,059	$666,286	$848,674	0.00%	5.86%		
DRO L Income ($55,905)	$401,503	$496,305	$577,503	$664,266	$769,573	0.00%	5.87%	$5,529	0.000
TSP L Income ($54,287)	$409,467	$484,335	$571,974	$666,068	$848,927	0.00%	5.86%		

Therefore, if the DRO (CLPM) L2040 was available at the inception of the actual TSP L Funds, our simulation shows she would be not only be better off as January 2010 but also over her career to retirement in 2038. Figure 7 displays the cumulative differences (BY10$) of the DRO (CLPM) L2040 with an initial balance of $55,905 over the TSP L2040 with an initial balance of $54,287, as well as the other DRO (CLPM) L Funds cumulative difference over their TSP counterparts.

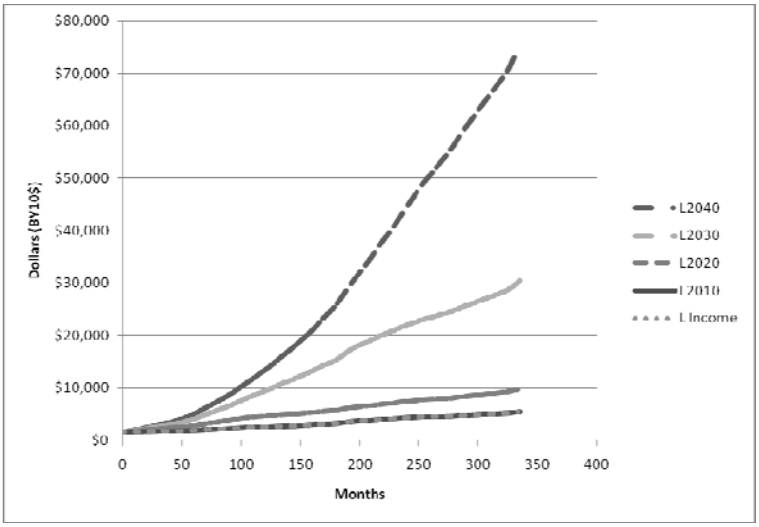

Figure 7: 32 year old L Fund Simulation: Cumulative Difference of DRO L Funds in Expected Portfolio Value (BY10$, $55,905 v. $54,287 Initial Balance)

The figures displaying this simulation's growth of all TSP and DRO (CLPM) L Funds in BY10$ are located in Appendix D. The probability chart of reaching her retirement goal with all ten L Funds is located in Appendix E.

42 year old, expecting to fully retire in 2030 (age 62)

In our last simulation model, we selected a new federal civilian employee (under the FERS retirement system), who just completed a 20 year military career. As such, he has been able to invest into the TSP since 1989 and as has a current balance of $125,000. He has decided to remain in the federal service and accepted a job as a civilian employee. Thus is still able to contribute to the TSP. He would like to retire in 2030 at the age of 62 and wants to transfer his existing TSP balance into an L Fund that will provide him the best chance of exceeding his retirement goal of $1.5 million. He is unsure if the TSP L2030 is the right asset allocation portfolio for his retirement but wants to protect his investment against unnecessary risk as much as possible. He has provided the following inputs in Table 11 for a simulation of all five L Fund pairs.

Table 11: 42 year old L Fund Simulation Model Inputs

		Current Year	**2010**
TSP balance (January 2010)	**$125,000**	**Current Age**	**42**
Initial Monthly Contribution (January 2010)	**$1,375**	**Year Entered Federal Service**	**1990**
Annual % Increase	**0.0%**	**Years Remaining in Career**	**20**
		Length in Months	**240**
Goal at Full Retirement	**$1,500,000**	**Full Retirement Age**	**62**
Goal at Full Retirement (BY10$)	**$880,405**	**Year at Full Retirement**	**2030**
		Years until Full Retirement	**20**
		Length in Months	**240**

Table 12: 42 year old L Fund Simulation Model Results (BY10$)

42 year old - Lifecycle (L) Fund Simulation: Goal at Retirement: $880,405 (BY10$)									
L Fund	Portfolio Min	5%	Portfolio Mean	95%	Portfolio Max	% chance of reaching retirement goal	Portfolio Mean APY	Portfolio Mean Difference	Student's t-test p-value
DRO L2040	$485,646	$690,539	$1,050,790	$1,530,806	$2,465,692	68.78%	6.95%	$62,494	0.000
TSP L2040	$403,141	$639,495	$988,296	$1,446,586	$2,136,182	59.12%	6.62%		
DRO L2030	$506,378	$675,885	$917,998	$1,226,335	$1,773,650	49.52%	6.23%	$26,652	0.000
TSP L2030	$447,884	$639,255	$891,345	$1,206,151	$1,673,495	42.46%	6.07%		
DRO L2020	$553,670	$653,051	$773,091	$912,147	$1,148,910	5.66%	5.32%	$5,249	0.002
TSP L2020	$546,229	$635,492	$767,842	$921,755	$1,143,336	6.62%	5.28%		
DRO L2010	$566,431	$643,691	$720,811	$805,492	$956,603	0.08%	4.95%	$401	0.698
TSP L2010	$566,605	$636,869	$720,410	$812,076	$935,933	0.02%	4.95%		
DRO L Income	$566,682	$643,635	$720,649	$805,416	$955,558	0.08%	4.95%	$385	0.709
TSP L Income	$566,815	$636,757	$720,264	$811,390	$936,255	0.02%	4.95%		

With an expected retirement date of 2030, this participant would be better off choosing the superior DRO (CLPM) L2030 Fund than the current TSP L2030 Fund as shown in Table 12 above. Not only does this fund offer have a better expected portfolio value at retirement of $26,662 (BY10$), but it also increases his chance of reaching a $1.5 million (TY$) goal at retirement by over 16%. Since the difference between the expected portfolio values of the DRO (CLPM) L2030 and TSP L2030 is statistically significant (p-value < 0.05), he would be better off to move his TSP balance into the asset allocation DRO (CLPM) L2030 Fund. Figure 8 depicts the cumulative difference growth of the DRO (CLPM) L2030 Fund and other DRO (CLPM) portfolios over the TSP L Funds from January 2010 to his expected retirement in 2030.

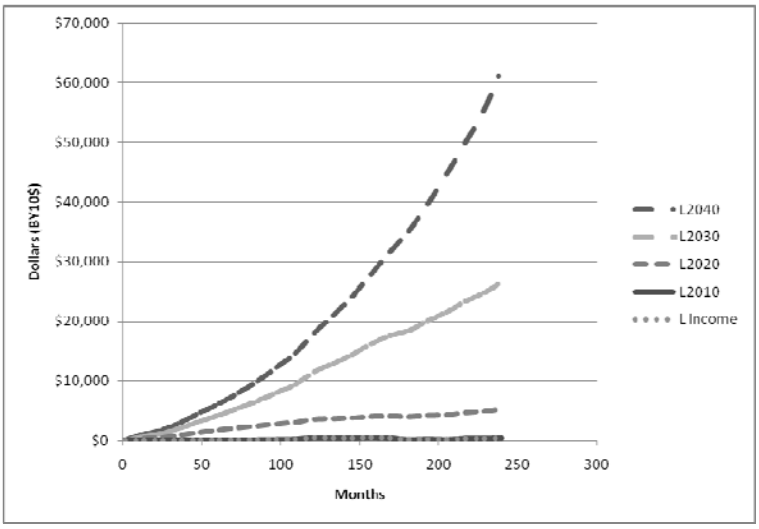

Figure 8: 42 year old L Fund Simulation Model: Cumulative Difference of DRO L Funds in Expected Portfolio Value (BY10$)

On the other hand, if this participant decided to have a greater allocation of the individual stock funds in his portfolio and was comfortable with the time horizon of the L2040 Fund, the DRO (CLPM) L2040 would be a superior choice to the TSP L2040. As displayed in Table 12, the DRO (CLPM) L2040 outgrows the TSP L2040 by $62,494 (BY10$), has a statistically significant different expected portfolio value at his retirement in 2030, and increases his chances of exceeding his goal at retirement by over 16%.

If this participant felt unsure about having a larger percent allocation of the C or S individual funds in either L2030 Fund, he could invest into the more conservative L2020 Fund. He would still have to wait until age 59 1/2 to withdraw any funds (to avoid the IRS penalty for early withdrawal), but would have a longer duration in either of the two L Income target allocations (DRO (CLPM) or TSP) once the L2020 Funds reach their time horizons in July 2020. If he was unsure of an expected retirement date in 2030 or uncomfortable with the allocation of the L2030 Funds, the DRO (CLPM) L2020 does provide a higher expected portfolio value at retirement than TSP L2020 by $5,249

(BY10$). The TSP L2020 does top the DRO (CLPM) L2020 in terms of increased chance in meeting his goal of $1.5 million (TY$) at retirement by almost 17%. The expected portfolio values of all ten L Funds in BY10$ and the probability tables of meeting his retirement goal and other various amounts in TY$ are provided in Appendices D and E, respectively.

In a one-way tornado graph of his inputs into the simulation model, his initial $125,000 TSP balance has the greatest impact on the DRO (CLPM) L2030 expected portfolio value (Appendix F). However, the one-way sensitivity analysis spider graph shows that each unit of change in initial monthly contribution causes the greatest unit change in his expected portfolio value. The spider graph shows the sensitivity of the expected portfolio value to unit changes in initial monthly contributions as a steeper slope to that of his initial TSP balance.

The results of our simulation model show that with his current TSP balance and initial monthly contribution, he will be expected to exceed his $1.5 million goal at retirement in 2030 with the DRO (CLPM) L2030 based on the two-way sensitivity analysis data tables in Appendix G. Since he is currently maximizing his monthly contributions and meeting the IRS annual contribution limit for 2010 of $16,500, he is unable to increase his monthly contributions. However, the IRS (401(k) Recourse Guide, 2009) does state that any future increases in the annual contribution limit for defined contribution plans, of which the TSP is a part of, will be indexed according to "cost-of-living increases." Therefore, it is possible he would be able to increase his monthly contributions in future years by the same percentage as the annual contribution limit is indexed from these cost-of-living adjustments. In addition, once this participant reaches

the age of 50 in eight years, he will be eligible for catch-up contributions to his selected DRO (CLPM) L Fund and/or TSP account. As of 2010, the IRS annual limit for catch-up contributions is $5,500, which added to the elective deferral limit equates to an annual limit of $22,000. At this limit, this participant would be able to increase his monthly contribution to no more than $1,833.33. The black dots within the data tables represent the simulation model's expected portfolio value for his DRO (CLPM) L2030 Fund and thus the base case for this sensitivity analysis. He could use the two-way data tables in Appendix G to see what alternate combinations of two of the three input variables would yield in expected mean balance of his DRO (CLPM) L2030 portfolio at retirement.

Model Analysis of Investor MAR (τ) – Sensitivity Analysis

For our DRO (CLPM) optimization models, we assumed an investor's MAR, or τ value, equal to an annual 2.7%. We associated this percentage with an inflation rate, thus our model's investors, we assumed, desired to earn at least an expected rate of return equal to inflation. For our sensitivity analysis of our optimization model's τ, we varied this investor input from zero percent to 8.1% annually (zero percent to .625% monthly). As stated in Chapter 3, the MAR or τ required by the investors has an effect on the DRO (CLPM) L Fund initial target allocations. We have found in our sensitivity analysis two interesting results. First, as τ increases, there is no change in the initial target allocations of the DRO (CLPM) L2040, L2030, or L2020 portfolios. The CLPM (risk measurement) for each portfolio does increase as τ increases, but varying τ up to an annual 8.1% does not affect any of the portfolios' allocations. Second, increasing τ does increase the

allocation of the G and C Funds while decreasing the allocation of the F Fund in both the DRO (CLPM) L2010 and L Income Funds. In our optimization models, we set our objective function to minimize CLPM risk measurement and meet a desired portfolio monthly return. Therefore, the DRO (CLPM) model tried to find the most efficient allocation for any particular L Fund. For the DRO (CLPM) L2040, L2030, and L2020 portfolios, the initial target allocations we found and highlighted in Chapter 3 (τ set at 2.7%) are still the most efficient allocation for the corresponding level of return from the actual TSP L Funds. However, for the L2010 and L Income Funds, the G Fund is least risky asset within the DRO (CLPM) L Fund. In order to meet an investor's higher τ, the optimization model increased the G Fund allocation as the fund provides a stable return for the level of risk assumed. If τ is even higher, the model must make up the difference in order to satisfy the constraints, of which the F Fund (the next least risky asset) cannot meet. Therefore, our models default to and increase the allocation of C Fund, the next most efficient asset, to meet the desired monthly portfolio return of the TSP L2010 and L Income Funds. This sensitivity analysis containing the tables of varying τ and corresponding DRO (CLPM) L Fund allocations, CLPM measurements, and expected monthly portfolio returns are located in Appendix H.

Model Validation

To validate our DRO (CLPM) findings in all three simulation models, we looked to actual TSP L Fund returns from the funds' inception in August 2005 through December 2009. Using a $1,000 a month investment and Equation 2.1, we calculated both the TSP L Fund portfolio balances (using the appropriate L Funds returns) and DRO

(CLPM) L Fund portfolio balances over this period. To calculate the DRO (CLPM) L Fund balances, we used the DRO (CLPM) quarterly target allocations from August 2005 through December 2009 and actual returns from the TSP individual funds in the same period. The DRO (CLPM) L Funds have outperformed each of the TSP L Funds in this period. It is clear that the 2008 recession did have a significant impact on each portfolio, but the DRO (CLPM) L Funds were able to minimize portfolio losses more than the TSP L Funds due to their conservative allocation. When the market rebounded, the DRO (CLPM) L Funds outpaced the TSP L Funds due to compounding interest and the fact each DRO portfolio was able to preserve more principal during the recession. As shown in Table 13, the smallest difference at the end of this period is $784 between the L Income Funds and the largest difference, $2,139, between the L2020 Funds.

Table 13: L Fund Portfolio Balances Since Inception ($1,000 monthly contribution)

L Fund	TSP	DRO (CLPM)	Difference
L2040	$54,287	$55,905	$1,618
L2030	$54,909	$56,693	$1,784
L2020	$55,625	$57,763	$2,139
L2010	$57,263	$58,152	$889
L Income	$57,518	$58,301	$784

It is important to note that 2005 was not the first year federal civilian employees or military members were able to contribute. Therefore, it is fair to state that some may have amassed a significant TSP balance and converted it to an L Funds in August 2005 to take advantage of an asset allocation, professionally managed portfolio. Given this, the TSP L2040 with a $100,000 initial balance transfer and $1,000 a month contribution would have experienced a $63,346 loss in a 17-month period leading up to and during the 2008 recession. On the other hand, the DRO (CLPM) L2040 only experienced a $32,000 loss in the same period. Because the DRO (CLPM) L2040 lost less in that 17-month

time period, the portfolio was able to capitalize and grow more due to a larger remaining principal and compounding interest than the TSP L2040 from February 2009 (end of the aforementioned time period) to the end of 2009. The results of our all model validations are located in Appendix I.

Conclusion

We created these three simulation models to show the broad applicability of DRO and the benefits of optimizing against downside risk versus the traditional MVO. By and large, participants are expected to have not only a greater chance of achieving their desired goal at retirement with the DRO (CLPM) L Funds, but can expect to earn higher returns. The DRO (CLPM) L Funds provide for higher expected portfolio values at retirement and, in some instances, statistically significant differences over the TSP L Funds. Over time, the DRO (CLPM) L Funds are able to outgrow their TSP counterparts by minimizing losses in months the funds experience poor returns and in subsequent months due to compounding interest and ability to preserve more principal.

Although we provided these simulations and analyses to demonstrate the effectiveness of optimizing the L Funds in DRO, specific inputs provided by our participants have large effect on the expected outcome of each L Fund. Our simulation models are adaptable for other participants and should serve as the foundation for the benefits of DRO. Federal civilian employees and military members should use this information to reassess their TSP investment strategies from time to time and understand the assertions of the L Funds posted by the TSP can be questioned in certain scenarios.

V. Conclusion

Research Overview

The purpose of this research was to apply, test, and analyze the downside risk optimization (DRO) model within the Thrift Savings Plan (TSP). At the author's research foundation was the definition of investor risk and how competing optimization theories minimize risk in order to create efficient portfolios. Using the assumptions of the Modern Portfolio Theory (MPT) and mean-variance optimization (MVO) variance definition of risk, the TSP L Funds pledge to provide the best expected return for the amount of expected risk that is appropriate for the its specific time horizon (FRTIB – Thrift Savings Plan, 2009:2). To investigate this claim, we applied the DRO model via the Co-Lower Partial Moment (CLPM) framework, and through non-linear programming, created DRO (CLPM) L Fund portfolio alternatives to the TSP L Funds.

By capturing various participant inputs and using Monte Carlo simulation of expected monthly returns, we estimated and compared the expected portfolio values of TSP L Funds and DRO (CLPM) L Funds at the retirement date for three typical TSP investors. We computed the probability of meeting their desired monetary goals at retirement with each L Fund and by applying a variety of statistical and sensitivity analyses, gained insight on what combinations of inputs would yield in expected portfolio value at retirement. The results from our analysis will assist those TSP participants who seek an asset allocation approach to investing, desire an L Fund with highest probability

of meeting their retirement goal, and want to minimize any unnecessary risk in their L Fund portfolios based on a specific time horizon.

Strengths and Limitations

The limitation of estimating future values of investments from historic returns is rooted in the investment adage that "*past performance is not an indication of future results.*" How the TSP individual funds and L Funds performed in the past is no representation of how each will perform in the future. To counter this adage, we fit specific statistical distributions to the historical TSP monthly return data and used Monte Carlo simulation to increase the independence of our models. Our distributions included a range of monthly returns from 15.58% to -20.99% and we ran each of our models through 5,000 iterations of Monte Carlo simulation to address any further weaknesses or dependence issues.

The simulations we created in Chapter 4, however, are limited by the assumptions of our models. We assumed that the model's three input variables (initial TSP balance, initial monthly contribution, and expected annual increase of monthly contributions) are known by the participant at the beginning of each simulation. Thus, once the simulation starts, our models were not dynamic enough to accept changes to the investor inputs. Also, our models did not account for the fact that TSP participants can both invest into an L Fund and as well as into any of the five individual TSP funds at the same time. In each simulation, we assumed our participants to invest 100% into the L Fund they selected based on their level of risk averseness and expected time horizon.

Despite those limitations, an important strength of our methodology and analysis pertained to the ease in changes the FRTIB would need to make to incorporate the DRO (CLPM) portfolios. As discussed in Chapter 3, our methodology of decrementing each L Fund to the L Income at its time horizon is the same methodology as the current TSP L Funds. The mechanism is in place to adjust the L Funds by the 1/100% each quarter as the target allocations change and become more conservative. Therefore, the FRTIB would only need to make small changes to the current L Funds and TSP structure if they chose to adopt the DRO (CLPM) portfolios and methodology. On the other hand, if the FRTIB and TSP gave the power to investors to manage their individual fund allocations at the same level as the L Funds, those who desire a DRO (CLPM) L Fund would be able to follow our methodology. Investors would be able to build and select our DRO (CLPM) L Fund portfolios in order to better suit their level of risk aversion and to meet their desired retirement goals. As of January 2010, individual TSP participants are only able to change the allocations of their accounts by the whole percentage. Despite that the quarterly target allocations of each L Fund are posted on the TSP website, individual investors cannot adjust their portfolio allocations to the same percentages as the L Fund quarterly target allocations.

Recommendations for Future Research

Notable future research efforts include extending this methodology and optimizing TSP portfolios that include both the individual funds and L Funds. A limitation of our research is that we only chose to optimize L Fund alternatives versus a

combination portfolio of the TSP L Funds and individual funds. A broader model that accepts the current TSP structure may be more ideal for today's investors. Another interesting area of future research in the DRO (CLPM) theory would be to optimize other funds into a TSP portfolio. The emergence in recent years of exchange-traded funds (ETF) and inverse funds have broadened the investment world. ETF funds follow indices like the TSP individual funds but are valued by investors due to their "stock-like" features and low administrative costs (Rongala, 2009). Inverse funds allow investors to "bet" against the market, investing in the market downturns rather the traditional "buy low, sell high" adage. Using the DRO (CLPM) theory, these funds could possibly create even more efficient TSP L Fund portfolios. A research effort that includes these two types of new investment funds, while testing the overall efficiency of the TSP, might yield interesting results as to if the TSP L Funds and individual funds are truly the best investment option for federal civilian employees and military members.

Conclusion

While the FRTIB designed the L Funds to be an efficient asset allocation approach in investing and saving for retirement, we have shown that L Funds created through DRO can improve the probability of meeting desired retirement goals as well as increase a portfolio's expected value at retirement. Simulating the same monthly returns for both sets of L Funds, we have revealed that a more conservative allocation and approach to investing can not only earn better returns but also minimize the risk exposure of any L Fund portfolio to the market.

If the FRTIB were to offer DRO (CLPM) L Funds as an alternative to the current TSP L Funds, TSP participation levels may increase. The TSP offers numerous benefits to participants and if the L Funds were to couple those with the benefits of DRO, federal civil service employees and military members may be more apt to choose the TSP as their investment vehicle for retirement. Thus, modifying the TSP structure from a "choice architecture" position may result in more civilian employees and military members choosing the asset allocation investing approach.

Despite these facts, every individual investor is unique. One investor's MAR may be different from that of another. Therefore, the DRO (CLPM) L Funds and the downside risk theory are dynamic. In the end, each investor must define his or her own level of risk aversion. The 2008 recession has made many investors question their investment strategies and portfolios. Offering an L Fund rooted in a theory that protects against downside losses may restore some confidence lost in those same investors. Ultimately, the DRO (CLPM) L Funds proved their efficiency over the TSP L Funds. Not only do investors have the opportunity for higher expected portfolio values at retirement than in any of the TSP L Funds, the DRO (CLPM) portfolios offer increased chances in achieving desired retirement goals, higher annual percentage yields, and better suit an investors aversion to portfolio risk.

Appendix A. Historic TSP Individual Funds, TSP Lifecycle Funds, and 90 day Treasury Bill Returns

Table 14: Historic TSP Individual Funds Returns

Last Trading Day	G Fund	F Fund	C Fund	S Fund (Wilshire 4500)	I Fund (EAFE)
19880129	0.6900%	-0.0600%	-0.2000%	4.5400%	1.7852%
19880229	0.0062%	0.8100%	4.8200%	6.5800%	6.6688%
19880331	0.6600%	-0.8000%	-3.4700%	1.8400%	6.1456%
19880429	0.6800%	-0.4600%	0.7300%	1.2700%	1.4509%
19880531	0.7100%	-0.6300%	1.4200%	-1.5300%	-3.2037%
19880630	0.7200%	1.9700%	4.0800%	6.1700%	-2.6355%
19880729	0.7200%	-0.4900%	-0.2400%	-1.5100%	3.1374%
19880831	0.7600%	0.3300%	-2.7400%	-1.8500%	-6.5021%
19880930	0.7600%	2.0700%	4.1200%	2.8200%	4.3681%
19881031	0.7500%	1.6800%	2.5300%	-0.2400%	8.5579%
19881130	0.6800%	-1.0900%	-1.2300%	-1.9400%	5.9566%
19881230	0.7400%	0.3100%	1.7800%	3.1800%	0.5557%
19890131	0.7600%	1.2700%	7.1400%	5.4800%	1.7611%
19890228	0.6700%	-0.6800%	-2.5100%	0.3500%	0.5143%
19890331	0.7800%	0.5000%	2.2100%	2.2600%	-1.9626%
19890428	0.7500%	2.0500%	5.1400%	4.3900%	0.9275%
19890531	0.7600%	2.4200%	3.9800%	3.6800%	-5.4422%
19890630	0.7000%	3.1900%	-0.5800%	-0.4800%	-1.6815%
19890731	0.6900%	2.0600%	8.8300%	5.0400%	12.5570%
19890831	0.6600%	-1.4800%	1.9800%	3.0200%	-4.4971%
19890929	0.6800%	0.3700%	-0.2900%	0.6500%	4.5531%
19891031	0.7100%	2.4500%	-2.3300%	-4.4100%	-4.0181%
19891130	0.6500%	0.8600%	2.0500%	1.1100%	5.0262%
19891229	0.6700%	0.1600%	2.3700%	0.9800%	3.6929%
19900131	0.6800%	-1.3800%	-6.5900%	-8.5300%	-3.7209%
19900228	0.6400%	0.2100%	1.2600%	2.1100%	-6.9795%
19900330	0.7200%	0.0100%	2.6400%	2.0900%	-10.4204%
19900430	0.7100%	-0.9400%	-2.5200%	-3.9500%	-0.7933%
19900531	0.7600%	2.8000%	9.4400%	7.4300%	11.4133%
19900629	0.7100%	1.5600%	-0.7100%	0.1000%	-0.8818%
19900731	0.7200%	1.2400%	-0.3600%	-2.5000%	1.4085%
19900831	0.7200%	-1.4200%	-8.6500%	-10.0500%	-9.7098%
19900928	0.7300%	0.8100%	-4.8500%	-6.7600%	-13.9365%
19901031	0.7600%	1.3200%	-0.4600%	-3.9000%	15.5793%
19901130	0.7000%	2.1500%	6.3600%	7.5700%	-5.9003%
19901231	0.7000%	1.4600%	2.7200%	3.8300%	1.6272%
19910131	0.6900%	1.1500%	4.5500%	6.0100%	3.2306%
19910228	0.6200%	0.8600%	7.0700%	9.1000%	10.7190%
19910328	0.6800%	0.6700%	2.4000%	4.3800%	-6.0045%
19910430	0.6600%	1.0500%	0.1800%	0.5700%	0.9842%
19910531	0.6800%	0.5700%	4.3000%	3.5000%	1.0463%
19910628	0.6600%	-0.0100%	-4.4900%	-4.3900%	-7.3475%
19910731	0.6900%	1.4000%	4.6300%	4.9300%	4.9121%
19910830	0.6900%	2.1200%	2.3700%	3.4800%	-2.0332%
19910930	0.6400%	1.9900%	-1.6300%	0.4300%	5.6374%
19911031	0.6200%	1.0900%	1.3900%	3.1100%	1.4158%
19911129	0.6100%	0.8900%	-3.9600%	-3.3600%	-4.6687%
19911231	0.6200%	2.9600%	11.4100%	9.9000%	5.1659%
19920131	0.5700%	-1.3500%	-1.8900%	3.5100%	-2.1341%
19920228	0.5600%	0.6600%	1.2900%	1.4800%	-3.5793%
19920331	0.6200%	-0.5300%	-1.9100%	-3.5700%	-6.6022%
19920430	0.6200%	0.6700%	2.9100%	-2.0900%	0.4704%
19920529	0.6400%	1.8400%	0.4900%	1.0700%	6.6934%
19920630	0.6000%	1.3600%	-1.4500%	-3.0600%	-4.7400%
19920731	0.6000%	2.0000%	4.1100%	3.7000%	-2.5593%
19920831	0.5700%	1.0000%	-2.0200%	-2.2100%	6.2721%
19920930	0.5400%	1.1500%	1.1500%	1.5600%	-1.9747%
19921030	0.5500%	-1.3000%	0.4200%	2.6600%	-5.2455%
19921130	0.5600%	0.0100%	3.3900%	5.8500%	0.9410%
19921231	0.5800%	1.5400%	1.2100%	2.8800%	0.5172%
19930129	0.5800%	1.8800%	0.8600%	2.1800%	-0.0123%
19930226	0.4900%	1.7300%	1.3500%	-1.6600%	3.0207%
19930331	0.5200%	0.4100%	2.0900%	3.5300%	8.7165%
19930430	0.5100%	0.6700%	-2.3900%	-3.2700%	9.4903%
19930528	0.5100%	0.1000%	2.6600%	4.1200%	2.1120%
19930630	0.5100%	1.7900%	0.3200%	0.8200%	-1.5602%
19930730	0.4900%	0.5500%	-0.3800%	0.5800%	3.5005%
19930831	0.4900%	1.7200%	3.7800%	4.5400%	5.3983%
19930930	0.4500%	0.2600%	-0.7600%	2.0500%	-2.2509%
19931029	0.4700%	0.3800%	2.0400%	1.1800%	3.0818%
19931130	0.4500%	-0.8400%	-0.9300%	-3.3600%	-8.7411%
19931231	0.4900%	0.5200%	1.2000%	3.3800%	7.2207%
19940131	0.5100%	1.3300%	3.4000%	2.7500%	8.4546%
19940228	0.4300%	-1.7200%	-2.7000%	-1.3800%	-0.2770%
19940331	0.5200%	-2.4500%	-4.3900%	-4.8900%	-4.3071%
19940429	0.5600%	-0.8100%	1.2800%	0.6000%	4.2429%
19940531	0.6000%	-0.0200%	1.6600%	-0.5400%	-0.5741%
19940630	0.5900%	-0.2400%	-2.4700%	-3.1200%	1.4132%
19940729	0.6200%	1.9700%	3.2700%	2.7000%	0.9617%
19940831	0.6000%	0.1300%	4.1100%	4.7700%	2.3675%
19940930	0.5900%	-1.4700%	-2.4400%	-0.6800%	-3.1496%
19941031	0.6500%	-0.1000%	2.2400%	0.4300%	3.3300%
19941130	0.6400%	-0.2300%	-3.6200%	-4.0400%	-4.8060%
19941230	0.6800%	0.6900%	1.4900%	1.1700%	0.6262%
19950131	0.6700%	1.9800%	2.5800%	0.9700%	-3.8415%
19950228	0.5900%	2.3800%	3.8700%	4.2500%	-0.2870%
19950331	0.6200%	0.6000%	2.9400%	2.2000%	6.2371%
19950428	0.6000%	1.3800%	2.9400%	1.2900%	3.7609%
19950531	0.6100%	3.8400%	3.9800%	2.2300%	-1.1921%
19950630	0.5300%	0.7100%	2.3100%	4.8200%	-1.7537%
19950731	0.5500%	-0.2300%	3.3000%	5.8800%	6.2256%
19950831	0.5600%	1.2100%	0.2600%	2.3300%	-3.8146%
19950929	0.5300%	0.9500%	4.1900%	2.7100%	1.9530%
19951031	0.5400%	1.2800%	-0.3600%	-2.6800%	-2.6880%
19951130	0.5100%	1.4900%	4.3800%	4.2500%	2.7824%
19951229	0.5000%	1.3900%	1.9200%	1.2600%	4.0290%
19960131	0.4900%	0.6600%	3.4100%	1.0300%	0.4105%
19960229	0.4600%	-1.7500%	0.9100%	3.2500%	0.3381%
19960329	0.5400%	-0.6800%	0.9700%	1.5300%	2.1236%
19960430	0.5400%	-0.5600%	1.4700%	4.6500%	2.9073%
19960531	0.5800%	-0.1100%	2.5600%	3.1500%	-1.8402%
19960628	0.5700%	1.3400%	0.3800%	-3.1400%	0.5628%
19960731	0.5800%	0.2700%	-4.3900%	-7.5100%	-2.9227%
19960830	0.5800%	-0.1800%	2.0700%	5.4000%	0.2191%
19960930	0.5800%	1.7200%	5.6000%	4.7700%	2.6566%
19961031	0.5800%	2.2100%	2.7400%	-1.4800%	-1.0233%
19961129	0.5300%	1.6900%	7.5400%	4.2200%	3.9789%
19961231	0.5300%	-0.9300%	-1.9700%	0.9000%	-1.2864%
19970131	0.5600%	0.3000%	6.2200%	3.2300%	-3.4998%
19970228	0.5100%	0.2400%	0.7900%	-2.1100%	1.6356%
19970331	0.5700%	-1.1100%	-4.1300%	-5.2200%	0.3621%
19970430	0.5800%	1.4900%	6.0000%	0.2500%	0.5306%
19970530	0.5800%	0.9400%	6.0700%	9.9500%	6.5074%
19970630	0.5600%	1.1800%	4.4500%	4.7400%	5.5148%
19970731	0.5700%	2.6900%	7.9400%	6.8800%	1.6177%
19970829	0.5300%	-0.8600%	-5.5900%	0.9100%	-7.4684%
19970930	0.5400%	1.4800%	5.4600%	6.9300%	5.6019%
19971031	0.5400%	1.4500%	-3.3800%	-3.8100%	-7.6865%
19971128	0.5000%	0.4600%	4.6100%	0.0300%	-1.0194%
19971231	0.5200%	1.0100%	1.7100%	2.4500%	0.8722%
19980130	0.5100%	1.2800%	1.1200%	-1.4300%	4.5734%
19980227	0.4400%	-0.0700%	7.2000%	7.6500%	6.4166%
19980331	0.5000%	0.3400%	5.1100%	5.1700%	3.0792%
19980430	0.4900%	0.5200%	1.0000%	1.2700%	0.7915%
19980529	0.5100%	0.9500%	-1.7200%	-4.6700%	-0.4854%
19980630	0.4800%	0.8500%	4.0500%	1.5600%	0.7570%
19980731	0.4900%	0.2100%	-1.0900%	-5.6600%	1.0139%
19980831	0.4900%	1.6600%	-14.4700%	-19.3800%	-12.3889%
19980930	0.4400%	2.3600%	6.3300%	7.2200%	-3.0658%
19981030	0.4100%	-0.5200%	8.1900%	5.6800%	10.4240%
19981130	0.4200%	0.5600%	6.0400%	6.2200%	5.1231%
19981231	0.4300%	0.3000%	5.7600%	8.4600%	3.9450%
19990129	0.4200%	0.7100%	4.1900%	1.6100%	-0.2953%
19990226	0.3800%	-1.7400%	-3.0900%	-5.4400%	-2.3833%
19990331	0.4700%	0.5400%	3.9900%	3.9000%	4.1742%
19990430	0.4600%	0.2900%	3.8600%	7.9800%	4.0519%
19990528	0.4700%	-0.8900%	-2.3600%	-0.8700%	-5.1499%
19990630	0.4900%	-0.3300%	5.5400%	4.2000%	3.8987%
19990730	0.5200%	-0.4300%	-3.1400%	-3.0300%	2.9723%
19990831	0.5300%	-0.0500%	-0.5000%	-2.4900%	0.3652%
19990930	0.5100%	1.1500%	-2.7800%	-0.7800%	1.0066%
19991029	0.5300%	0.3800%	6.3400%	5.1100%	3.7456%
19991130	0.5100%	-0.0100%	2.0000%	8.4400%	3.4745%
19991231	0.5400%	-0.4500%	5.9000%	13.7800%	8.9752%
20000131	0.5600%	-0.3400%	-5.0300%	-1.2000%	-6.3539%
20000229	0.5300%	1.2200%	-1.9300%	15.5500%	2.6920%
20000331	0.5500%	1.3200%	9.7400%	-3.7000%	3.8764%
20000428	0.5200%	-0.2900%	-2.9800%	-12.0300%	-5.2623%
20000531	0.5400%	-0.0300%	-2.0500%	-7.3800%	-2.4424%
20000630	0.5300%	2.0700%	2.4400%	12.0100%	3.9108%
20000731	0.5300%	0.8900%	-1.5600%	-2.8400%	-4.1925%
20000831	0.5200%	1.4600%	6.1900%	11.1600%	0.8680%
20000929	0.4900%	0.6400%	-5.2700%	-4.0700%	-4.8692%
20001031	0.5100%	0.6600%	-0.4000%	-8.1700%	-2.3622%
20001130	0.4800%	1.6500%	-7.8700%	-17.0300%	-3.7500%
20001229	0.4800%	1.8600%	0.5000%	6.3300%	3.5544%
20010131	0.4600%	1.6500%	3.5500%	5.4400%	-0.0516%
20010228	0.4200%	0.8700%	-9.1200%	-12.1500%	-7.4968%
20010330	0.4500%	0.5100%	-6.3300%	-9.1800%	-6.6661%
20010430	0.4300%	-0.4200%	7.7800%	10.5800%	6.9492%
20010531	0.4700%	0.6100%	0.6500%	1.4200%	-4.1300%
20010629	0.4700%	0.3900%	-2.4200%	0.6600%	-3.9900%
20010731	0.4800%	2.2200%	-0.9800%	-4.1300%	-1.7900%
20010831	0.4500%	1.2000%	-6.2700%	-4.3200%	-2.5800%
20010928	0.4300%	1.1500%	-8.0500%	-12.5000%	-9.9500%
20011031	0.4100%	2.1200%	1.8500%	5.0900%	2.4700%
20011130	0.3700%	-1.3700%	7.6200%	7.8400%	3.5600%
20011231	0.4200%	-0.6100%	0.8800%	5.3100%	0.5200%
20020131	0.4500%	0.7900%	-1.4700%	-2.0200%	-5.3300%
20020228	0.4000%	0.9800%	-1.9200%	-2.6400%	0.6600%
20020328	0.4400%	-1.6600%	3.7300%	6.8300%	5.8200%
20020430	0.4600%	1.8900%	-6.0600%	-1.0600%	0.2500%
20020531	0.4500%	0.8800%	-0.7500%	-2.3900%	1.2900%
20020628	0.4300%	0.9700%	-7.1000%	-6.6700%	-3.8700%
20020731	0.4300%	1.1900%	-7.7000%	-9.9300%	-9.9900%
20020830	0.4000%	1.5800%	0.6700%	0.5800%	-0.2600%
20020930	0.3700%	1.6300%	-10.8700%	-6.8400%	-10.7500%
20021031	0.3300%	-0.4400%	8.7700%	3.3800%	5.4200%
20021129	0.3400%	-0.0100%	5.8700%	6.7600%	4.4900%
20021231	0.3800%	2.0800%	-5.8500%	-4.3200%	-3.2700%
20030131	0.3500%	0.1000%	-2.6700%	-2.3500%	-4.2400%
20030228	0.3200%	1.4100%	-1.4900%	-2.5600%	-2.2900%
20030331	0.3300%	-0.0500%	0.9700%	1.5500%	-1.9000%
20030430	0.3300%	0.8300%	8.2600%	8.3100%	9.8200%
20030530	0.3400%	1.8700%	5.2600%	9.4200%	6.0700%
20030630	0.2000%	-0.3000%	1.2000%	2.2000%	2.3000%
20030731	0.3000%	-3.4100%	1.7800%	4.6000%	2.3500%
20030829	0.4000%	0.7300%	1.9400%	4.1200%	2.3900%
20030930	0.4000%	2.6800%	-1.1400%	-1.3500%	3.0800%
20031031	0.3000%	-1.0000%	5.6800%	7.6500%	6.0600%
20031128	0.3000%	0.3000%	0.9100%	3.4700%	2.2200%
20031231	0.4900%	1.0100%	5.2400%	2.0400%	7.6800%

Last Trading Day	G Fund	F Fund	C Fund	S Fund (Wilshire 4500)	I Fund (EAFE)
20040130	0.2900%	0.8000%	1.8000%	3.5300%	1.3200%
20040227	0.3900%	1.0900%	1.3500%	1.7800%	2.2200%
20040331	0.2900%	0.6900%	-1.5000%	0.3800%	0.6000%
20040430	0.2900%	-2.5400%	-1.5200%	-3.9400%	-2.3100%
20040528	0.3900%	-0.5000%	1.3700%	1.5000%	0.3000%
20040630	0.3800%	0.6000%	1.8600%	2.7200%	2.8900%
20040730	0.3800%	1.0000%	-3.2400%	-5.5200%	-3.7600%
20040831	0.3800%	1.8800%	0.3400%	0.0000%	1.0000%
20040930	0.3800%	0.2900%	1.1100%	3.9200%	2.0500%
20041029	0.3800%	0.8700%	1.5200%	1.8500%	3.9400%
20041130	0.2800%	-0.8600%	4.0800%	6.9600%	6.1600%
20041231	0.3800%	0.9700%	3.3600%	4.1700%	4.3800%
20050131	0.3700%	0.5800%	-2.4000%	-3.3900%	-1.8700%
20050228	0.3700%	-0.5700%	2.0600%	2.0400%	4.3400%
20050331	0.3700%	-0.4800%	-1.7100%	-1.8600%	-2.5200%
20050429	0.3700%	1.3500%	-1.9000%	-3.7200%	-2.2700%
20050531	0.3700%	1.0500%	3.1500%	6.0500%	-0.4000%
20050630	0.2800%	0.5600%	0.1600%	3.3700%	1.8600%
20050729	0.3700%	-0.8400%	3.6700%	5.5900%	3.0700%
20050831	0.3700%	1.2300%	-0.9000%	-1.0100%	3.2300%
20050930	0.3600%	-1.0300%	0.8400%	0.8300%	3.6800%
20051031	0.3600%	-0.7500%	-1.6600%	-2.3300%	-2.9000%
20051130	0.3600%	0.3800%	3.7500%	4.7200%	2.4400%
20051230	0.4500%	0.9500%	0.0700%	0.3700%	4.6400%
20060131	0.3600%	0.0900%	2.6600%	6.7000%	6.1400%
20060228	0.3600%	0.2800%	0.2200%	-0.9800%	-0.2700%
20060331	0.3600%	-0.9300%	1.2900%	3.8400%	3.3300%
20060428	0.4400%	-0.1900%	1.3500%	0.3400%	4.8300%
20060531	0.4400%	-0.0900%	-2.8700%	-4.3600%	-3.8700%
20060630	0.4400%	0.1900%	0.0700%	0.4700%	0.0000%
20060731	0.4400%	1.3200%	0.6500%	-2.7900%	0.9800%
20060831	0.4400%	1.5800%	2.3600%	2.1500%	2.7600%
20060929	0.3500%	0.8200%	2.5800%	0.8800%	0.1500%
20061031	0.4300%	0.7300%	3.2700%	4.9900%	3.8700%
20061130	0.4300%	1.0800%	1.9100%	3.5400%	2.9600%
20061229	0.3400%	-0.5400%	1.4200%	0.1100%	3.1100%
20070131	0.4300%	0.0000%	1.5300%	3.1400%	1.3100%
20070228	0.3400%	1.5300%	-1.9500%	-0.2600%	0.1800%
20070330	0.4200%	0.0000%	1.0900%	1.0900%	2.5700%
20070430	0.4200%	0.5300%	4.4300%	2.5100%	3.7600%
20070531	0.3400%	-0.7000%	3.5200%	4.4000%	2.5400%
20070629	0.4200%	-0.2700%	-1.7000%	-1.5300%	0.2000%
20070731	0.5000%	0.8000%	-3.1000%	-4.5700%	-2.3900%
20070831	0.3300%	1.2300%	1.5400%	1.3800%	-0.7100%
20070928	0.4100%	0.7800%	3.7600%	2.9700%	5.3600%
20071031	0.4100%	0.8600%	1.5800%	2.8300%	4.4900%
20071130	0.3300%	1.8800%	-4.2000%	-5.6500%	-3.7200%
20071231	0.4100%	0.2500%	-0.6600%	-0.4000%	-2.2500%
20080131	0.3300%	1.7600%	-5.9800%	-6.2700%	-8.5200%
20080229	0.2400%	0.1600%	-3.2800%	-2.0500%	-0.6600%
20080331	0.3200%	0.3300%	-0.4600%	-1.4300%	0.1800%
20080430	0.2400%	-0.1600%	4.9400%	5.3000%	5.5500%
20080530	0.3200%	-0.7400%	1.2700%	4.8800%	1.0900%
20080630	0.3200%	-0.0800%	-8.4100%	-7.6300%	-8.1500%
20080731	0.4000%	-0.0100%	-0.8000%	-0.7900%	-3.7200%
20080829	0.3300%	0.9200%	1.4600%	2.1700%	-4.1600%
20080930	0.3100%	-1.3100%	-8.9400%	-10.3200%	-12.3100%
20081031	0.3100%	-2.4000%	-16.8300%	-20.9900%	-20.5900%
20081128	0.3100%	3.3000%	-7.1800%	-11.1300%	-6.7200%
20081231	0.2400%	3.7300%	1.0700%	4.6800%	7.6600%
20090130	0.1900%	-0.8600%	-8.4100%	-8.1900%	-11.9300%
20090227	0.2100%	-0.3900%	-10.6400%	-10.2200%	-10.2300%
20090331	0.2400%	1.3800%	8.8100%	8.6400%	7.2000%
20090430	0.2100%	0.4900%	9.5800%	15.0000%	12.1300%
20090529	0.2500%	0.7800%	5.6000%	3.9700%	13.4100%
20090630	0.2700%	0.5400%	0.2400%	0.7300%	-1.0800%
20090731	0.2800%	1.5900%	7.5800%	8.6600%	9.7400%
20090831	0.2800%	1.0300%	3.6200%	3.8500%	4.8700%
20090930	0.2600%	1.0700%	3.7400%	5.9400%	3.7900%
20091030	0.2600%	0.5100%	-1.8600%	-5.5100%	-2.4100%
20091130	0.2600%	1.3000%	6.0000%	3.8500%	3.1600%
20091231	0.2500%	-1.5500%	1.9400%	6.5700%	1.4300%

Table 15: Historic TSP Lifecycle Funds Returns

Last Trading Day	L Income	L 2010	L 2020	L 2030	L 2040
20050831	0.1700%	0.1600%	0.1500%	0.0700%	0.0700%
20050930	0.5200%	0.9400%	1.0600%	1.1700%	1.3500%
20051031	-0.1700%	-0.9300%	-1.3400%	-1.6700%	-1.9000%
20051130	1.0300%	1.8900%	2.4200%	2.8000%	3.0800%
20051230	0.5900%	0.9300%	1.1100%	1.2200%	1.3200%
20060131	1.1000%	2.2200%	2.9200%	3.4000%	3.8400%
20060228	0.2500%	0.1500%	0.0700%	0.0000%	-0.0700%
20060331	0.6700%	1.1900%	1.5600%	1.7100%	1.9800%
20060428	0.7400%	1.1800%	1.4700%	1.6200%	1.7500%
20060531	-0.3300%	-1.3100%	-2.0600%	-2.4500%	-2.8700%
20060630	0.3300%	0.3700%	0.2800%	0.2700%	0.2600%
20060731	0.4900%	0.3700%	0.3500%	0.2000%	0.1300%
20060831	0.9000%	1.3900%	1.8100%	1.9600%	2.2200%
20060929	0.7300%	1.0100%	1.1700%	1.3300%	1.4100%
20061031	1.0400%	1.7900%	2.5100%	2.9400%	3.2800%
20061130	0.7900%	1.3400%	1.7800%	2.0300%	2.3200%
20061229	0.6300%	0.9000%	1.1700%	1.1800%	1.3100%
20070131	0.6300%	0.8900%	1.2200%	1.4200%	1.5300%
20070228	0.1600%	-0.1400%	-0.3800%	-0.4900%	-0.6400%
20070330	0.6200%	0.8900%	1.0800%	1.1600%	1.3400%
20070430	1.0800%	1.7600%	2.5800%	2.9500%	3.2800%
20070531	0.9200%	1.5300%	2.1500%	2.3200%	2.7900%
20070629	0.0800%	-0.2000%	-0.5400%	-0.8000%	-0.9200%
20070731	-0.2300%	-0.9200%	-1.7500%	-2.1300%	-2.5200%
20070831	0.6100%	0.7300%	0.8000%	0.8800%	0.9000%
20070928	1.1300%	1.7800%	2.6800%	3.0900%	3.4500%
20071031	0.8200%	1.2900%	1.8400%	2.0900%	2.3700%
20071130	-0.4400%	-0.1300%	-2.3300%	-2.9400%	-3.3600%
20071231	0.0700%	0.9000%	-0.5400%	-0.6300%	-0.8200%
20080131	-0.9700%	-2.0700%	-3.9000%	-4.7000%	-5.3700%
20080229	-0.2200%	-0.5900%	-1.2500%	-1.5100%	-1.8000%
20080331	0.2300%	0.0700%	-0.0600%	-0.1800%	-0.2900%
20080430	1.2000%	1.9300%	3.2300%	3.7400%	4.2600%
20080530	0.5900%	0.7800%	1.2300%	1.4800%	1.6500%
20080630	-1.4700%	-2.6500%	-4.9700%	-5.8800%	-6.7000%
20080731	0.0000%	-0.2300%	-0.8200%	-1.0700%	-1.3100%
20080829	0.3500%	0.2900%	0.1600%	0.1700%	0.1100%
20080930	-1.7500%	-3.0000%	-6.0100%	-7.2400%	-8.3500%
20081031	-3.4400%	-5.4100%	-11.1000%	-13.4000%	-15.4000%
20081128	-0.8400%	-1.5800%	-3.9100%	-4.9600%	-5.8500%
20081231	1.2100%	1.6600%	2.8200%	3.2400%	3.6300%
20090130	-1.7400%	-2.6100%	-5.5800%	-6.6900%	-7.6700%
20090227	-1.9800%	-2.9500%	-6.2200%	-7.4700%	-8.5200%
20090331	2.0600%	2.8200%	5.3500%	6.3000%	7.0800%
20090430	2.3700%	3.2000%	6.7900%	8.2000%	9.3800%
20090529	1.7000%	2.2800%	4.6600%	5.4500%	6.1900%
20090630	0.2600%	0.2400%	0.1400%	0.1200%	0.0900%
20090731	1.9400%	2.4400%	5.1600%	6.1600%	7.0100%
20090831	1.0700%	1.3000%	2.5700%	3.0200%	3.4100%
20090930	1.0800%	1.3200%	2.6300%	3.1400%	3.5600%
20091030	-0.2600%	-0.3800%	-1.3900%	-1.8100%	-2.1500%
20091130	1.2700%	1.4700%	3.0000%	3.5500%	3.9800%
20091231	0.5900%	0.7000%	1.5000%	1.8500%	2.1200%

Table 16: Historic 90 day T-Bill Returns

Month	90 day T-Bill
Feb-88	0.4717%
Mar-88	0.4750%
Apr-88	0.4925%
May-88	0.5217%
Jun-88	0.5383%
Jul-88	0.5608%
Aug-88	0.5883%
Sep-88	0.6033%
Oct-88	0.6125%
Nov-88	0.6467%
Dec-88	0.6725%
Jan-89	0.6892%
Feb-89	0.7108%
Mar-89	0.7350%
Apr-89	0.7208%
May-89	0.7025%
Jun-89	0.6792%
Jul-89	0.6567%
Aug-89	0.6583%
Sep-89	0.6458%
Oct-89	0.6367%
Nov-89	0.6408%
Dec-89	0.6358%
Jan-90	0.6367%
Feb-90	0.6450%
Mar-90	0.6583%
Apr-90	0.6475%
May-90	0.6450%
Jun-90	0.6442%
Jul-90	0.6350%
Aug-90	0.6208%
Sep-90	0.6133%
Oct-90	0.5975%
Nov-90	0.5883%
Dec-90	0.5617%
Jan-91	0.5183%
Feb-91	0.4950%
Mar-91	0.4925%
Apr-91	0.4708%
May-91	0.4550%
Jun-91	0.4642%
Jul-91	0.4650%
Aug-91	0.4442%
Sep-91	0.4350%
Oct-91	0.4158%
Nov-91	0.3800%
Dec-91	0.3392%
Jan-92	0.3167%
Feb-92	0.3200%
Mar-92	0.3367%
Apr-92	0.3125%
May-92	0.3025%
Jun-92	0.3050%
Jul-92	0.2675%
Aug-92	0.2608%
Sep-92	0.2425%
Oct-92	0.2383%
Nov-92	0.2608%
Dec-92	0.2683%
Jan-93	0.2500%
Feb-93	0.2442%
Mar-93	0.2458%
Apr-93	0.2392%
May-93	0.2467%
Jun-93	0.2558%
Jul-93	0.2533%
Aug-93	0.2517%
Sep-93	0.2458%
Oct-93	0.2517%
Nov-93	0.2583%
Dec-93	0.2550%
Jan-94	0.2483%
Feb-94	0.2708%
Mar-94	0.2917%
Apr-94	0.3067%
May-94	0.3450%
Jun-94	0.3450%
Jul-94	0.3608%
Aug-94	0.3733%
Sep-94	0.3850%
Oct-94	0.4125%
Nov-94	0.4408%
Dec-94	0.4667%
Jan-95	0.4758%
Feb-95	0.4808%
Mar-95	0.4775%
Apr-95	0.4708%
May-95	0.4725%
Jun-95	0.4558%
Jul-95	0.4517%
Aug-95	0.4500%
Sep-95	0.4400%
Oct-95	0.4400%
Nov-95	0.4467%
Dec-95	0.4283%
Jan-96	0.4167%
Feb-96	0.4025%
Mar-96	0.4133%
Apr-96	0.4125%
May-96	0.4183%
Jun-96	0.4242%
Jul-96	0.4292%
Aug-96	0.4208%
Sep-96	0.4242%
Oct-96	0.4158%
Nov-96	0.4192%
Dec-96	0.4092%
Jan-97	0.4192%
Feb-97	0.4175%
Mar-97	0.4283%
Apr-97	0.4300%
May-97	0.4208%
Jun-97	0.4108%
Jul-97	0.4208%
Aug-97	0.4283%
Sep-97	0.4125%
Oct-97	0.4142%
Nov-97	0.4283%
Dec-97	0.4300%
Jan-98	0.4200%
Feb-98	0.4242%
Mar-98	0.4192%
Apr-98	0.4125%
May-98	0.4167%
Jun-98	0.4150%
Jul-98	0.4133%
Aug-98	0.4083%
Sep-98	0.3842%
Oct-98	0.3300%
Nov-98	0.3675%
Dec-98	0.3658%
Jan-99	0.3617%
Feb-99	0.3700%
Mar-99	0.3700%
Apr-99	0.3575%
May-99	0.3750%
Jun-99	0.3808%
Jul-99	0.3792%
Aug-99	0.3933%
Sep-99	0.3900%
Oct-99	0.4050%
Nov-99	0.4225%
Dec-99	0.4333%
Jan-00	0.4433%
Feb-00	0.4625%
Mar-00	0.4742%
Apr-00	0.4717%
May-00	0.4825%
Jun-00	0.4742%
Jul-00	0.4967%
Aug-00	0.5075%
Sep-00	0.5000%
Oct-00	0.5092%
Nov-00	0.5142%
Dec-00	0.4808%
Jan-01	0.4292%
Feb-01	0.4067%
Mar-01	0.3683%
Apr-01	0.3225%
May-01	0.3017%
Jun-01	0.2908%
Jul-01	0.2925%
Aug-01	0.2800%
Sep-01	0.2200%
Oct-01	0.1800%
Nov-01	0.1558%
Dec-01	0.1408%
Jan-02	0.1375%
Feb-02	0.1442%
Mar-02	0.1492%
Apr-02	0.1433%
May-02	0.1442%
Jun-02	0.1417%
Jul-02	0.1400%
Aug-02	0.1350%
Sep-02	0.1358%
Oct-02	0.1317%
Nov-02	0.1025%
Dec-02	0.0992%
Jan-03	0.0975%
Feb-03	0.0975%
Mar-03	0.0942%
Apr-03	0.0942%
May-03	0.0892%
Jun-03	0.0767%
Jul-03	0.0750%
Aug-03	0.0792%
Sep-03	0.0783%
Oct-03	0.0767%
Nov-03	0.0775%
Dec-03	0.0750%
Jan-04	0.0733%
Feb-04	0.0775%
Mar-04	0.0783%
Apr-04	0.0783%
May-04	0.0850%
Jun-04	0.1058%
Jul-04	0.1108%
Aug-04	0.1233%
Sep-04	0.1375%
Oct-04	0.1467%
Nov-04	0.1725%
Dec-04	0.1825%
Jan-05	0.1942%
Feb-05	0.2117%
Mar-05	0.2283%
Apr-05	0.2317%
May-05	0.2367%
Jun-05	0.2475%
Jul-05	0.2683%
Aug-05	0.2867%
Sep-05	0.2850%
Oct-05	0.3092%
Nov-05	0.3233%
Dec-05	0.3242%
Jan-06	0.3533%
Feb-06	0.3692%
Mar-06	0.3758%
Apr-06	0.3833%
May-06	0.3933%
Jun-06	0.3992%
Jul-06	0.4125%
Aug-06	0.4133%
Sep-06	0.4008%
Oct-06	0.4100%
Nov-06	0.4117%
Dec-06	0.4042%
Jan-07	0.4150%
Feb-07	0.4192%
Mar-07	0.4117%
Apr-07	0.4058%
May-07	0.3942%
Jun-07	0.3842%
Jul-07	0.4017%
Aug-07	0.3500%
Sep-07	0.3242%
Oct-07	0.3250%
Nov-07	0.2725%
Dec-07	0.2500%
Jan-08	0.2292%
Feb-08	0.1767%
Mar-08	0.1050%
Apr-08	0.1075%
May-08	0.1442%
Jun-08	0.1550%
Jul-08	0.1358%
Aug-08	0.1433%
Sep-08	0.0942%
Oct-08	0.0558%
Nov-08	0.0158%
Dec-08	0.0025%
Jan-09	0.0108%
Feb-09	0.0250%
Mar-09	0.0175%
Apr-09	0.0133%
May-09	0.0150%
Jun-09	0.0150%
Jul-09	0.0150%
Aug-09	0.0142%
Sep-09	0.0100%
Oct-09	0.0058%
Nov-09	0.0042%
Dec-09	0.0042%

Appendix B. DRO (CLPM) L Fund / TSP L Fund Quarterly Allocation Targets

Table 17: DRO (CLPM) L Fund Quarterly Allocation Targets

DRO L2040 Quarterly Allocation Targets

	G Fund	F Fund	C Fund	S Fund	I Fund
Jan-10	0.00%	46.60%	53.40%	0.00%	0.00%
Apr-10	0.00%	46.80%	53.20%	0.00%	0.00%
Jul-10	0.00%	47.00%	53.00%	0.00%	0.00%
Oct-10	0.00%	47.20%	52.80%	0.00%	0.00%
Jan-11	0.00%	47.40%	52.60%	0.00%	0.00%
Apr-11	0.00%	47.60%	52.40%	0.00%	0.00%
Jul-11	0.00%	47.80%	52.20%	0.00%	0.00%
Oct-11	0.00%	48.00%	52.00%	0.00%	0.00%
Jan-12	0.00%	48.20%	51.80%	0.00%	0.00%
Apr-12	0.00%	48.40%	51.60%	0.00%	0.00%
Jul-12	0.00%	48.60%	51.40%	0.00%	0.00%
Oct-12	0.00%	48.80%	51.20%	0.00%	0.00%
Jan-13	0.00%	49.00%	51.00%	0.00%	0.00%
Apr-13	0.00%	49.20%	50.80%	0.00%	0.00%
Jul-13	0.00%	49.40%	50.60%	0.00%	0.00%
Oct-13	0.00%	49.60%	50.40%	0.00%	0.00%
Jan-14	0.00%	49.80%	50.20%	0.00%	0.00%
Apr-14	0.00%	50.00%	50.00%	0.00%	0.00%
Jul-14	0.00%	50.20%	49.80%	0.00%	0.00%
Oct-14	0.00%	50.40%	49.60%	0.00%	0.00%
Jan-15	0.00%	50.60%	49.40%	0.00%	0.00%
Apr-15	0.00%	50.80%	49.20%	0.00%	0.00%
Jul-15	0.00%	51.00%	49.00%	0.00%	0.00%
Oct-15	0.00%	51.28%	48.73%	0.00%	0.00%
Jan-16	0.00%	51.55%	48.45%	0.00%	0.00%
Apr-16	0.00%	51.83%	48.18%	0.00%	0.00%
Jul-16	0.00%	52.10%	47.90%	0.00%	0.00%
Oct-16	0.00%	52.38%	47.63%	0.00%	0.00%
Jan-17	0.00%	52.65%	47.35%	0.00%	0.00%
Apr-17	0.00%	52.93%	47.08%	0.00%	0.00%
Jul-17	0.00%	53.20%	46.80%	0.00%	0.00%
Oct-17	0.00%	53.48%	46.53%	0.00%	0.00%
Jan-18	0.00%	53.75%	46.25%	0.00%	0.00%
Apr-18	0.00%	54.03%	45.98%	0.00%	0.00%
Jul-18	0.00%	54.30%	45.70%	0.00%	0.00%
Oct-18	0.00%	54.58%	45.43%	0.00%	0.00%
Jan-19	0.00%	54.85%	45.15%	0.00%	0.00%
Apr-19	0.00%	55.13%	44.88%	0.00%	0.00%
Jul-19	0.00%	55.40%	44.60%	0.00%	0.00%
Oct-19	0.00%	55.68%	44.33%	0.00%	0.00%
Jan-20	0.00%	55.95%	44.05%	0.00%	0.00%
Apr-20	0.00%	56.23%	43.78%	0.00%	0.00%
Jul-20	0.00%	56.50%	43.50%	0.00%	0.00%
Oct-20	0.00%	56.78%	43.23%	0.00%	0.00%
Jan-21	0.00%	57.05%	42.95%	0.00%	0.00%
Apr-21	0.00%	57.33%	42.68%	0.00%	0.00%
Jul-21	0.00%	57.60%	42.40%	0.00%	0.00%
Oct-21	0.00%	57.88%	42.13%	0.00%	0.00%
Jan-22	0.00%	58.15%	41.85%	0.00%	0.00%
Apr-22	0.00%	58.43%	41.58%	0.00%	0.00%
Jul-22	0.00%	58.70%	41.30%	0.00%	0.00%
Oct-22	0.00%	58.98%	41.03%	0.00%	0.00%
Jan-23	0.00%	59.25%	40.75%	0.00%	0.00%
Apr-23	0.00%	59.53%	40.48%	0.00%	0.00%
Jul-23	0.00%	59.80%	40.20%	0.00%	0.00%
Oct-23	0.00%	60.08%	39.93%	0.00%	0.00%
Jan-24	0.00%	60.35%	39.65%	0.00%	0.00%
Apr-24	0.00%	60.63%	39.38%	0.00%	0.00%
Jul-24	0.00%	60.90%	39.10%	0.00%	0.00%
Oct-24	0.00%	61.18%	38.83%	0.00%	0.00%
Jan-25	0.00%	61.45%	38.55%	0.00%	0.00%
Apr-25	0.00%	61.73%	38.28%	0.00%	0.00%
Jul-25	0.00%	62.00%	38.00%	0.00%	0.00%
Oct-25	0.03%	62.35%	37.60%	0.03%	0.00%
Jan-26	0.05%	62.70%	37.20%	0.05%	0.00%
Apr-26	0.08%	63.05%	36.80%	0.08%	0.00%
Jul-26	0.10%	63.40%	36.40%	0.10%	0.00%
Oct-26	0.13%	63.75%	36.00%	0.13%	0.00%
Jan-27	0.15%	64.10%	35.60%	0.15%	0.00%
Apr-27	0.18%	64.45%	35.20%	0.18%	0.00%
Jul-27	0.20%	64.80%	34.80%	0.20%	0.00%
Oct-27	0.23%	65.15%	34.40%	0.23%	0.00%
Jan-28	0.25%	65.50%	34.00%	0.25%	0.00%
Apr-28	0.28%	65.85%	33.60%	0.28%	0.00%
Jul-28	0.30%	66.20%	33.20%	0.30%	0.00%
Oct-28	0.33%	66.55%	32.80%	0.33%	0.00%
Jan-29	0.35%	66.90%	32.40%	0.35%	0.00%
Apr-29	0.38%	67.25%	32.00%	0.38%	0.00%
Jul-29	0.40%	67.60%	31.60%	0.40%	0.00%
Oct-29	0.43%	67.95%	31.20%	0.43%	0.00%
Jan-30	0.45%	68.30%	30.80%	0.45%	0.00%
Apr-30	0.48%	68.65%	30.40%	0.48%	0.00%
Jul-30	0.50%	69.00%	30.00%	0.50%	0.00%
Oct-30	0.53%	69.35%	29.60%	0.53%	0.00%
Jan-31	0.55%	69.70%	29.20%	0.55%	0.00%
Apr-31	0.58%	70.05%	28.80%	0.58%	0.00%
Jul-31	0.60%	70.40%	28.40%	0.60%	0.00%
Oct-31	0.63%	70.75%	28.00%	0.63%	0.00%
Jan-32	0.65%	71.10%	27.60%	0.65%	0.00%
Apr-32	0.68%	71.45%	27.20%	0.68%	0.00%
Jul-32	0.70%	71.80%	26.80%	0.70%	0.00%
Oct-32	0.73%	72.15%	26.40%	0.73%	0.00%
Jan-33	0.75%	72.50%	26.00%	0.75%	0.00%
Apr-33	0.78%	72.85%	25.60%	0.78%	0.00%
Jul-33	0.80%	73.20%	25.20%	0.80%	0.00%
Oct-33	0.83%	73.55%	24.80%	0.83%	0.00%
Jan-34	0.85%	73.90%	24.40%	0.85%	0.00%
Apr-34	0.88%	74.25%	24.00%	0.88%	0.00%
Jul-34	0.90%	74.60%	23.60%	0.90%	0.00%
Oct-34	0.93%	74.95%	23.20%	0.93%	0.00%
Jan-35	0.95%	75.30%	22.80%	0.95%	0.00%
Apr-35	0.98%	75.65%	22.40%	0.98%	0.00%
Jul-35	1.00%	76.00%	22.00%	1.00%	0.00%
Oct-35	3.75%	73.90%	21.35%	1.00%	0.00%
Jan-36	6.50%	71.80%	20.70%	1.00%	0.00%
Apr-36	9.25%	69.70%	20.05%	1.00%	0.00%
Jul-36	12.00%	67.60%	19.40%	1.00%	0.00%
Oct-36	14.75%	65.50%	18.75%	1.00%	0.00%
Jan-37	17.50%	63.40%	18.10%	1.00%	0.00%
Apr-37	20.25%	61.30%	17.45%	1.00%	0.00%
Jul-37	23.00%	59.20%	16.80%	1.00%	0.00%
Oct-37	25.75%	57.10%	16.15%	1.00%	0.00%
Jan-38	28.50%	55.00%	15.50%	1.00%	0.00%
Apr-38	31.25%	52.90%	14.85%	1.00%	0.00%
Jul-38	34.00%	50.80%	14.20%	1.00%	0.00%
Oct-38	36.75%	48.70%	13.55%	1.00%	0.00%
Jan-39	39.50%	46.60%	12.90%	1.00%	0.00%
Apr-39	42.25%	44.50%	12.25%	1.00%	0.00%
Jul-39	45.00%	42.40%	11.60%	1.00%	0.00%
Oct-39	47.75%	40.30%	10.95%	1.00%	0.00%
Jan-40	50.50%	38.20%	10.30%	1.00%	0.00%
Apr-40	53.25%	36.10%	9.65%	1.00%	0.00%
Jul-40	56.00%	34.00%	9.00%	1.00%	0.00%

DRO L2030 Quarterly Allocation Targets

	G Fund	F Fund	C Fund	S Fund	I Fund
Jan-10	0.00%	55.95%	44.05%	0.00%	0.00%
Apr-10	0.00%	56.23%	43.78%	0.00%	0.00%
Jul-10	0.00%	56.50%	43.50%	0.00%	0.00%
Oct-10	0.00%	56.78%	43.23%	0.00%	0.00%
Jan-11	0.00%	57.05%	42.95%	0.00%	0.00%
Apr-11	0.00%	57.33%	42.68%	0.00%	0.00%
Jul-11	0.00%	57.60%	42.40%	0.00%	0.00%
Oct-11	0.00%	57.88%	42.13%	0.00%	0.00%
Jan-12	0.00%	58.15%	41.85%	0.00%	0.00%
Apr-12	0.00%	58.43%	41.58%	0.00%	0.00%
Jul-12	0.00%	58.70%	41.30%	0.00%	0.00%
Oct-12	0.00%	58.98%	41.03%	0.00%	0.00%
Jan-13	0.00%	59.25%	40.75%	0.00%	0.00%
Apr-13	0.00%	59.53%	40.48%	0.00%	0.00%
Jul-13	0.00%	59.80%	40.20%	0.00%	0.00%
Oct-13	0.00%	60.08%	39.93%	0.00%	0.00%
Jan-14	0.00%	60.35%	39.65%	0.00%	0.00%
Apr-14	0.00%	60.63%	39.38%	0.00%	0.00%
Jul-14	0.00%	60.90%	39.10%	0.00%	0.00%
Oct-14	0.00%	61.18%	38.83%	0.00%	0.00%
Jan-15	0.00%	61.45%	38.55%	0.00%	0.00%
Apr-15	0.00%	61.73%	38.28%	0.00%	0.00%
Jul-15	0.00%	62.00%	38.00%	0.00%	0.00%
Oct-15	0.03%	62.35%	37.60%	0.03%	0.00%
Jan-16	0.05%	62.70%	37.20%	0.05%	0.00%
Apr-16	0.08%	63.05%	36.80%	0.08%	0.00%
Jul-16	0.10%	63.40%	36.40%	0.10%	0.00%
Oct-16	0.13%	63.75%	36.00%	0.13%	0.00%
Jan-17	0.15%	64.10%	35.60%	0.15%	0.00%
Apr-17	0.18%	64.45%	35.20%	0.18%	0.00%
Jul-17	0.20%	64.80%	34.80%	0.20%	0.00%
Oct-17	0.23%	65.15%	34.40%	0.23%	0.00%
Jan-18	0.25%	65.50%	34.00%	0.25%	0.00%
Apr-18	0.28%	65.85%	33.60%	0.28%	0.00%
Jul-18	0.30%	66.20%	33.20%	0.30%	0.00%
Oct-18	0.33%	66.55%	32.80%	0.33%	0.00%
Jan-19	0.35%	66.90%	32.40%	0.35%	0.00%
Apr-19	0.38%	67.25%	32.00%	0.38%	0.00%
Jul-19	0.40%	67.60%	31.60%	0.40%	0.00%
Oct-19	0.43%	67.95%	31.20%	0.43%	0.00%
Jan-20	0.45%	68.30%	30.80%	0.45%	0.00%
Apr-20	0.48%	68.65%	30.40%	0.48%	0.00%
Jul-20	0.50%	69.00%	30.00%	0.50%	0.00%
Oct-20	0.53%	69.35%	29.60%	0.53%	0.00%
Jan-21	0.55%	69.70%	29.20%	0.55%	0.00%
Apr-21	0.58%	70.05%	28.80%	0.58%	0.00%
Jul-21	0.60%	70.40%	28.40%	0.60%	0.00%
Oct-21	0.63%	70.75%	28.00%	0.63%	0.00%
Jan-22	0.65%	71.10%	27.60%	0.65%	0.00%
Apr-22	0.68%	71.45%	27.20%	0.68%	0.00%
Jul-22	0.70%	71.80%	26.80%	0.70%	0.00%
Oct-22	0.73%	72.15%	26.40%	0.73%	0.00%
Jan-23	0.75%	72.50%	26.00%	0.75%	0.00%
Apr-23	0.78%	72.85%	25.60%	0.78%	0.00%
Jul-23	0.80%	73.20%	25.20%	0.80%	0.00%
Oct-23	0.83%	73.55%	24.80%	0.83%	0.00%
Jan-24	0.85%	73.90%	24.40%	0.85%	0.00%
Apr-24	0.88%	74.25%	24.00%	0.88%	0.00%
Jul-24	0.90%	74.60%	23.60%	0.90%	0.00%
Oct-24	0.93%	74.95%	23.20%	0.93%	0.00%
Jan-25	0.95%	75.30%	22.80%	0.95%	0.00%
Apr-25	0.98%	75.65%	22.40%	0.98%	0.00%
Jul-25	1.00%	76.00%	22.00%	1.00%	0.00%
Oct-25	3.75%	73.90%	21.35%	1.00%	0.00%
Jan-26	6.50%	71.80%	20.70%	1.00%	0.00%
Apr-26	9.25%	69.70%	20.05%	1.00%	0.00%
Jul-26	12.00%	67.60%	19.40%	1.00%	0.00%
Oct-26	14.75%	65.50%	18.75%	1.00%	0.00%
Jan-27	17.50%	63.40%	18.10%	1.00%	0.00%
Apr-27	20.25%	61.30%	17.45%	1.00%	0.00%
Jul-27	23.00%	59.20%	16.80%	1.00%	0.00%
Oct-27	25.75%	57.10%	16.15%	1.00%	0.00%
Jan-28	28.50%	55.00%	15.50%	1.00%	0.00%
Apr-28	31.25%	52.90%	14.85%	1.00%	0.00%
Jul-28	34.00%	50.80%	14.20%	1.00%	0.00%
Oct-28	36.75%	48.70%	13.55%	1.00%	0.00%
Jan-29	39.50%	46.60%	12.90%	1.00%	0.00%
Apr-29	42.25%	44.50%	12.25%	1.00%	0.00%
Jul-29	45.00%	42.40%	11.60%	1.00%	0.00%
Oct-29	47.75%	40.30%	10.95%	1.00%	0.00%
Jan-30	50.50%	38.20%	10.30%	1.00%	0.00%
Apr-30	53.25%	36.10%	9.65%	1.00%	0.00%
Jul-30	56.00%	34.00%	9.00%	1.00%	0.00%

DRO L2020 Quarterly Allocation Targets

	G Fund	F Fund	C Fund	S Fund	I Fund
Jan-10	0.45%	68.30%	30.80%	0.45%	0.00%
Apr-10	0.48%	68.65%	30.40%	0.48%	0.00%
Jul-10	0.50%	69.00%	30.00%	0.50%	0.00%
Oct-10	0.53%	69.35%	29.60%	0.53%	0.00%
Jan-11	0.55%	69.70%	29.20%	0.55%	0.00%
Apr-11	0.58%	70.05%	28.80%	0.58%	0.00%
Jul-11	0.60%	70.40%	28.40%	0.60%	0.00%
Oct-11	0.63%	70.75%	28.00%	0.63%	0.00%
Jan-12	0.65%	71.10%	27.60%	0.65%	0.00%
Apr-12	0.68%	71.45%	27.20%	0.68%	0.00%
Jul-12	0.70%	71.80%	26.80%	0.70%	0.00%
Oct-12	0.73%	72.15%	26.40%	0.73%	0.00%
Jan-13	0.75%	72.50%	26.00%	0.75%	0.00%
Apr-13	0.78%	72.85%	25.60%	0.78%	0.00%
Jul-13	0.80%	73.20%	25.20%	0.80%	0.00%
Oct-13	0.83%	73.55%	24.80%	0.83%	0.00%
Jan-14	0.85%	73.90%	24.40%	0.85%	0.00%
Apr-14	0.88%	74.25%	24.00%	0.88%	0.00%
Jul-14	0.90%	74.60%	23.60%	0.90%	0.00%
Oct-14	0.93%	74.95%	23.20%	0.93%	0.00%
Jan-15	0.95%	75.30%	22.80%	0.95%	0.00%
Apr-15	0.98%	75.65%	22.40%	0.98%	0.00%
Jul-15	1.00%	76.00%	22.00%	1.00%	0.00%
Oct-15	3.75%	73.90%	21.35%	1.00%	0.00%
Jan-16	6.50%	71.80%	20.70%	1.00%	0.00%
Apr-16	9.25%	69.70%	20.05%	1.00%	0.00%
Jul-16	12.00%	67.60%	19.40%	1.00%	0.00%
Oct-16	14.75%	65.50%	18.75%	1.00%	0.00%
Jan-17	17.50%	63.40%	18.10%	1.00%	0.00%
Apr-17	20.25%	61.30%	17.45%	1.00%	0.00%
Jul-17	23.00%	59.20%	16.80%	1.00%	0.00%
Oct-17	25.75%	57.10%	16.15%	1.00%	0.00%
Jan-18	28.50%	55.00%	15.50%	1.00%	0.00%
Apr-18	31.25%	52.90%	14.85%	1.00%	0.00%
Jul-18	34.00%	50.80%	14.20%	1.00%	0.00%
Oct-18	36.75%	48.70%	13.55%	1.00%	0.00%
Jan-19	39.50%	46.60%	12.90%	1.00%	0.00%
Apr-19	42.25%	44.50%	12.25%	1.00%	0.00%
Jul-19	45.00%	42.40%	11.60%	1.00%	0.00%
Oct-19	47.75%	40.30%	10.95%	1.00%	0.00%
Jan-20	50.50%	38.20%	10.30%	1.00%	0.00%
Apr-20	53.25%	36.10%	9.65%	1.00%	0.00%
Jul-20	56.00%	34.00%	9.00%	1.00%	0.00%

DRO L2010 Quarterly Allocation Targets

	G Fund	F Fund	C Fund	S Fund	I Fund
Jan-10	50.50%	38.20%	10.30%	1.00%	0.00%
Apr-10	53.25%	36.10%	9.65%	1.00%	0.00%
Jul-10	56.00%	34.00%	9.00%	1.00%	0.00%

DRO L Income Quarterly Allocation Targets

	G Fund	F Fund	C Fund	S Fund	I Fund
Jan-10	56.00%	34.00%	9.00%	1.00%	0.00%

Table 18: TSP L Fund Quarterly Allocation Targets

TSP L2040 Quarterly Allocation Targets

	G Fund	F Fund	C Fund	S Fund	I Fund
Jan-10	9.95%	9.55%	40.20%	17.10%	23.20%
Apr-10	10.22%	9.53%	40.10%	17.05%	23.10%
Jul-10	10.50%	9.50%	40.00%	17.00%	23.00%
Oct-10	10.77%	9.48%	39.90%	16.95%	22.90%
Jan-11	11.05%	9.45%	39.80%	16.90%	22.80%
Apr-11	11.32%	9.43%	39.70%	16.85%	22.70%
Jul-11	11.60%	9.40%	39.60%	16.80%	22.60%
Oct-11	11.87%	9.38%	39.50%	16.75%	22.50%
Jan-12	12.15%	9.35%	39.40%	16.70%	22.40%
Apr-12	12.42%	9.33%	39.30%	16.65%	22.30%
Jul-12	12.70%	9.30%	39.20%	16.60%	22.20%
Oct-12	12.97%	9.28%	39.10%	16.55%	22.10%
Jan-13	13.25%	9.25%	39.00%	16.50%	22.00%
Apr-13	13.52%	9.23%	38.90%	16.45%	21.90%
Jul-13	13.80%	9.20%	38.80%	16.40%	21.80%
Oct-13	14.07%	9.18%	38.70%	16.35%	21.70%
Jan-14	14.35%	9.15%	38.60%	16.30%	21.60%
Apr-14	14.62%	9.13%	38.50%	16.25%	21.50%
Jul-14	14.90%	9.10%	38.40%	16.20%	21.40%
Oct-14	15.17%	9.08%	38.30%	16.15%	21.30%
Jan-15	15.45%	9.05%	38.20%	16.10%	21.20%
Apr-15	15.72%	9.03%	38.10%	16.05%	21.10%
Jul-15	16.00%	9.00%	38.00%	16.00%	21.00%
Oct-15	16.27%	8.98%	37.90%	15.90%	20.95%
Jan-16	16.55%	8.95%	37.80%	15.80%	20.90%
Apr-16	16.82%	8.93%	37.70%	15.70%	20.85%
Jul-16	17.10%	8.90%	37.60%	15.60%	20.80%
Oct-16	17.37%	8.88%	37.50%	15.50%	20.75%
Jan-17	17.65%	8.85%	37.40%	15.40%	20.70%
Apr-17	17.92%	8.83%	37.30%	15.30%	20.65%
Jul-17	18.20%	8.80%	37.20%	15.20%	20.60%
Oct-17	18.47%	8.78%	37.10%	15.10%	20.55%
Jan-18	18.75%	8.75%	37.00%	15.00%	20.50%
Apr-18	19.02%	8.73%	36.90%	14.90%	20.45%
Jul-18	19.30%	8.70%	36.80%	14.80%	20.40%
Oct-18	19.57%	8.68%	36.70%	14.70%	20.35%
Jan-19	19.85%	8.65%	36.60%	14.60%	20.30%
Apr-19	20.12%	8.63%	36.50%	14.50%	20.25%
Jul-19	20.40%	8.60%	36.40%	14.40%	20.20%
Oct-19	20.67%	8.58%	36.30%	14.30%	20.15%
Jan-20	20.95%	8.55%	36.20%	14.20%	20.10%
Apr-20	21.22%	8.53%	36.10%	14.10%	20.05%
Jul-20	21.50%	8.50%	36.00%	14.00%	20.00%
Oct-20	21.77%	8.48%	35.90%	13.90%	19.95%
Jan-21	22.05%	8.45%	35.80%	13.80%	19.90%
Apr-21	22.32%	8.43%	35.70%	13.70%	19.85%
Jul-21	22.60%	8.40%	35.60%	13.60%	19.80%
Oct-21	22.87%	8.38%	35.50%	13.50%	19.75%
Jan-22	23.15%	8.35%	35.40%	13.40%	19.70%
Apr-22	23.42%	8.33%	35.30%	13.30%	19.65%
Jul-22	23.70%	8.30%	35.20%	13.20%	19.60%
Oct-22	23.97%	8.28%	35.10%	13.10%	19.55%
Jan-23	24.25%	8.25%	35.00%	13.00%	19.50%
Apr-23	24.52%	8.23%	34.90%	12.90%	19.45%
Jul-23	24.80%	8.20%	34.80%	12.80%	19.40%
Oct-23	25.07%	8.18%	34.70%	12.70%	19.35%
Jan-24	25.35%	8.15%	34.60%	12.60%	19.30%
Apr-24	25.62%	8.13%	34.50%	12.50%	19.25%
Jul-24	25.90%	8.10%	34.40%	12.40%	19.20%
Oct-24	26.17%	8.08%	34.30%	12.30%	19.15%
Jan-25	26.45%	8.05%	34.20%	12.20%	19.10%
Apr-25	26.72%	8.03%	34.10%	12.10%	19.05%
Jul-25	27.00%	8.00%	34.00%	12.00%	19.00%
Oct-25	27.40%	7.98%	33.82%	11.90%	18.90%
Jan-26	27.80%	7.95%	33.65%	11.80%	18.80%
Apr-26	28.20%	7.93%	33.47%	11.70%	18.70%
Jul-26	28.60%	7.90%	33.30%	11.60%	18.60%
Oct-26	29.00%	7.88%	33.12%	11.50%	18.50%
Jan-27	29.40%	7.85%	32.95%	11.40%	18.40%
Apr-27	29.80%	7.83%	32.77%	11.30%	18.30%
Jul-27	30.20%	7.80%	32.60%	11.20%	18.20%
Oct-27	30.60%	7.78%	32.42%	11.10%	18.10%
Jan-28	31.00%	7.75%	32.25%	11.00%	18.00%
Apr-28	31.40%	7.73%	32.07%	10.90%	17.90%
Jul-28	31.80%	7.70%	31.90%	10.80%	17.80%
Oct-28	32.20%	7.68%	31.72%	10.70%	17.70%
Jan-29	32.60%	7.65%	31.55%	10.60%	17.60%
Apr-29	33.00%	7.63%	31.37%	10.50%	17.50%
Jul-29	33.40%	7.60%	31.20%	10.40%	17.40%
Oct-29	33.80%	7.58%	31.02%	10.30%	17.30%
Jan-30	34.20%	7.55%	30.85%	10.20%	17.20%
Apr-30	34.60%	7.53%	30.67%	10.10%	17.10%
Jul-30	35.00%	7.50%	30.50%	10.00%	17.00%
Oct-30	35.40%	7.48%	30.32%	9.90%	16.90%
Jan-31	35.80%	7.45%	30.15%	9.80%	16.80%
Apr-31	36.20%	7.43%	29.97%	9.70%	16.70%
Jul-31	36.60%	7.40%	29.80%	9.60%	16.60%
Oct-31	37.00%	7.38%	29.62%	9.50%	16.50%
Jan-32	37.40%	7.35%	29.45%	9.40%	16.40%
Apr-32	37.80%	7.33%	29.27%	9.30%	16.30%
Jul-32	38.20%	7.30%	29.10%	9.20%	16.20%
Oct-32	38.60%	7.28%	28.92%	9.10%	16.10%
Jan-33	39.00%	7.25%	28.75%	9.00%	16.00%
Apr-33	39.40%	7.23%	28.57%	8.90%	15.90%
Jul-33	39.80%	7.20%	28.40%	8.80%	15.80%
Oct-33	40.20%	7.18%	28.22%	8.70%	15.70%
Jan-34	40.60%	7.15%	28.05%	8.60%	15.60%
Apr-34	41.00%	7.13%	27.87%	8.50%	15.50%
Jul-34	41.40%	7.10%	27.70%	8.40%	15.40%
Oct-34	41.80%	7.08%	27.52%	8.30%	15.30%
Jan-35	42.20%	7.05%	27.35%	8.20%	15.20%
Apr-35	42.60%	7.03%	27.17%	8.10%	15.10%
Jul-35	43.00%	7.00%	27.00%	8.00%	15.00%
Oct-35	44.55%	6.95%	26.25%	7.75%	14.50%
Jan-36	46.10%	6.90%	25.50%	7.50%	14.00%
Apr-36	47.65%	6.85%	24.75%	7.25%	13.50%
Jul-36	49.20%	6.80%	24.00%	7.00%	13.00%
Oct-36	50.75%	6.75%	23.25%	6.75%	12.50%
Jan-37	52.30%	6.70%	22.50%	6.50%	12.00%
Apr-37	53.85%	6.65%	21.75%	6.25%	11.50%
Jul-37	55.40%	6.60%	21.00%	6.00%	11.00%
Oct-37	56.95%	6.55%	20.25%	5.75%	10.50%
Jan-38	58.50%	6.50%	19.50%	5.50%	10.00%
Apr-38	60.05%	6.45%	18.75%	5.25%	9.50%
Jul-38	61.60%	6.40%	18.00%	5.00%	9.00%
Oct-38	63.15%	6.35%	17.25%	4.75%	8.50%
Jan-39	64.70%	6.30%	16.50%	4.50%	8.00%
Apr-39	66.25%	6.25%	15.75%	4.25%	7.50%
Jul-39	67.80%	6.20%	15.00%	4.00%	7.00%
Oct-39	69.35%	6.15%	14.25%	3.75%	6.50%
Jan-40	70.90%	6.10%	13.50%	3.50%	6.00%
Apr-40	72.45%	6.05%	12.75%	3.25%	5.50%
Jul-40	74.00%	6.00%	12.00%	3.00%	5.00%

TSP L2030 Quarterly Allocation Targets

	G Fund	F Fund	C Fund	S Fund	I Fund
Jan-10	20.95%	8.55%	36.20%	14.20%	20.10%
Apr-10	21.22%	8.53%	36.10%	14.10%	20.05%
Jul-10	21.50%	8.50%	36.00%	14.00%	20.00%
Oct-10	21.77%	8.48%	35.90%	13.90%	19.95%
Jan-11	22.05%	8.45%	35.80%	13.80%	19.90%
Apr-11	22.32%	8.43%	35.70%	13.70%	19.85%
Jul-11	22.60%	8.40%	35.60%	13.60%	19.80%
Oct-11	22.87%	8.38%	35.50%	13.50%	19.75%
Jan-12	23.15%	8.35%	35.40%	13.40%	19.70%
Apr-12	23.42%	8.33%	35.30%	13.30%	19.65%
Jul-12	23.70%	8.30%	35.20%	13.20%	19.60%
Oct-12	23.97%	8.28%	35.10%	13.10%	19.55%
Jan-13	24.25%	8.25%	35.00%	13.00%	19.50%
Apr-13	24.52%	8.23%	34.90%	12.90%	19.45%
Jul-13	24.80%	8.20%	34.80%	12.80%	19.40%
Oct-13	25.07%	8.18%	34.70%	12.70%	19.35%
Jan-14	25.35%	8.15%	34.60%	12.60%	19.30%
Apr-14	25.62%	8.13%	34.50%	12.50%	19.25%
Jul-14	25.90%	8.10%	34.40%	12.40%	19.20%
Oct-14	26.17%	8.08%	34.30%	12.30%	19.15%
Jan-15	26.45%	8.05%	34.20%	12.20%	19.10%
Apr-15	26.72%	8.03%	34.10%	12.10%	19.05%
Jul-15	27.00%	8.00%	34.00%	12.00%	19.00%
Oct-15	27.40%	7.98%	33.82%	11.90%	18.90%
Jan-16	27.80%	7.95%	33.65%	11.80%	18.80%
Apr-16	28.20%	7.93%	33.47%	11.70%	18.70%
Jul-16	28.60%	7.90%	33.30%	11.60%	18.60%
Oct-16	29.00%	7.88%	33.12%	11.50%	18.50%
Jan-17	29.40%	7.85%	32.95%	11.40%	18.40%
Apr-17	29.80%	7.83%	32.77%	11.30%	18.30%
Jul-17	30.20%	7.80%	32.60%	11.20%	18.20%
Oct-17	30.60%	7.78%	32.42%	11.10%	18.10%
Jan-18	31.00%	7.75%	32.25%	11.00%	18.00%
Apr-18	31.40%	7.73%	32.07%	10.90%	17.90%
Jul-18	31.80%	7.70%	31.90%	10.80%	17.80%
Oct-18	32.20%	7.68%	31.72%	10.70%	17.70%
Jan-19	32.60%	7.65%	31.55%	10.60%	17.60%
Apr-19	33.00%	7.63%	31.37%	10.50%	17.50%
Jul-19	33.40%	7.60%	31.20%	10.40%	17.40%
Oct-19	33.80%	7.58%	31.02%	10.30%	17.30%
Jan-20	34.20%	7.55%	30.85%	10.20%	17.20%
Apr-20	34.60%	7.53%	30.67%	10.10%	17.10%
Jul-20	35.00%	7.50%	30.50%	10.00%	17.00%
Oct-20	35.40%	7.48%	30.32%	9.90%	16.90%
Jan-21	35.80%	7.45%	30.15%	9.80%	16.80%
Apr-21	36.20%	7.43%	29.97%	9.70%	16.70%
Jul-21	36.60%	7.40%	29.80%	9.60%	16.60%
Oct-21	37.00%	7.38%	29.62%	9.50%	16.50%
Jan-22	37.40%	7.35%	29.45%	9.40%	16.40%
Apr-22	37.80%	7.33%	29.27%	9.30%	16.30%
Jul-22	38.20%	7.30%	29.10%	9.20%	16.20%
Oct-22	38.60%	7.28%	28.92%	9.10%	16.10%
Jan-23	39.00%	7.25%	28.75%	9.00%	16.00%
Apr-23	39.40%	7.23%	28.57%	8.90%	15.90%
Jul-23	39.80%	7.20%	28.40%	8.80%	15.80%
Oct-23	40.20%	7.18%	28.22%	8.70%	15.70%
Jan-24	40.60%	7.15%	28.05%	8.60%	15.60%
Apr-24	41.00%	7.13%	27.87%	8.50%	15.50%
Jul-24	41.40%	7.10%	27.70%	8.40%	15.40%
Oct-24	41.80%	7.08%	27.52%	8.30%	15.30%
Jan-25	42.20%	7.05%	27.35%	8.20%	15.20%
Apr-25	42.60%	7.03%	27.17%	8.10%	15.10%
Jul-25	43.00%	7.00%	27.00%	8.00%	15.00%
Oct-25	44.55%	6.95%	26.25%	7.75%	14.50%
Jan-26	46.10%	6.90%	25.50%	7.50%	14.00%
Apr-26	47.65%	6.85%	24.75%	7.25%	13.50%
Jul-26	49.20%	6.80%	24.00%	7.00%	13.00%
Oct-26	50.75%	6.75%	23.25%	6.75%	12.50%
Jan-27	52.30%	6.70%	22.50%	6.50%	12.00%
Apr-27	53.85%	6.65%	21.75%	6.25%	11.50%
Jul-27	55.40%	6.60%	21.00%	6.00%	11.00%
Oct-27	56.95%	6.55%	20.25%	5.75%	10.50%
Jan-28	58.50%	6.50%	19.50%	5.50%	10.00%
Apr-28	60.05%	6.45%	18.75%	5.25%	9.50%
Jul-28	61.60%	6.40%	18.00%	5.00%	9.00%
Oct-28	63.15%	6.35%	17.25%	4.75%	8.50%
Jan-29	64.70%	6.30%	16.50%	4.50%	8.00%
Apr-29	66.25%	6.25%	15.75%	4.25%	7.50%
Jul-29	67.80%	6.20%	15.00%	4.00%	7.00%
Oct-29	69.35%	6.15%	14.25%	3.75%	6.50%
Jan-30	70.90%	6.10%	13.50%	3.50%	6.00%
Apr-30	72.45%	6.05%	12.75%	3.25%	5.50%
Jul-30	74.00%	6.00%	12.00%	3.00%	5.00%

TSP L2020 Quarterly Allocation Targets

	G Fund	F Fund	C Fund	S Fund	I Fund
Jan-10	34.20%	7.55%	30.85%	10.20%	17.20%
Apr-10	34.60%	7.53%	30.67%	10.10%	17.10%
Jul-10	35.00%	7.50%	30.50%	10.00%	17.00%
Oct-10	35.40%	7.48%	30.32%	9.90%	16.90%
Jan-11	35.80%	7.45%	30.15%	9.80%	16.80%
Apr-11	36.20%	7.43%	29.97%	9.70%	16.70%
Jul-11	36.60%	7.40%	29.80%	9.60%	16.60%
Oct-11	37.00%	7.38%	29.62%	9.50%	16.50%
Jan-12	37.40%	7.35%	29.45%	9.40%	16.40%
Apr-12	37.80%	7.33%	29.27%	9.30%	16.30%
Jul-12	38.20%	7.30%	29.10%	9.20%	16.20%
Oct-12	38.60%	7.28%	28.92%	9.10%	16.10%
Jan-13	39.00%	7.25%	28.75%	9.00%	16.00%
Apr-13	39.40%	7.23%	28.57%	8.90%	15.90%
Jul-13	39.80%	7.20%	28.40%	8.80%	15.80%
Oct-13	40.20%	7.18%	28.22%	8.70%	15.70%
Jan-14	40.60%	7.15%	28.05%	8.60%	15.60%
Apr-14	41.00%	7.13%	27.87%	8.50%	15.50%
Jul-14	41.40%	7.10%	27.70%	8.40%	15.40%
Oct-14	41.80%	7.08%	27.52%	8.30%	15.30%
Jan-15	42.20%	7.05%	27.35%	8.20%	15.20%
Apr-15	42.60%	7.03%	27.17%	8.10%	15.10%
Jul-15	43.00%	7.00%	27.00%	8.00%	15.00%
Oct-15	44.55%	6.95%	26.25%	7.75%	14.50%
Jan-16	46.10%	6.90%	25.50%	7.50%	14.00%
Apr-16	47.65%	6.85%	24.75%	7.25%	13.50%
Jul-16	49.20%	6.80%	24.00%	7.00%	13.00%
Oct-16	50.75%	6.75%	23.25%	6.75%	12.50%
Jan-17	52.30%	6.70%	22.50%	6.50%	12.00%
Apr-17	53.85%	6.65%	21.75%	6.25%	11.50%
Jul-17	55.40%	6.60%	21.00%	6.00%	11.00%
Oct-17	56.95%	6.55%	20.25%	5.75%	10.50%
Jan-18	58.50%	6.50%	19.50%	5.50%	10.00%
Apr-18	60.05%	6.45%	18.75%	5.25%	9.50%
Jul-18	61.60%	6.40%	18.00%	5.00%	9.00%
Oct-18	63.15%	6.35%	17.25%	4.75%	8.50%
Jan-19	64.70%	6.30%	16.50%	4.50%	8.00%
Apr-19	66.25%	6.25%	15.75%	4.25%	7.50%
Jul-19	67.80%	6.20%	15.00%	4.00%	7.00%
Oct-19	69.35%	6.15%	14.25%	3.75%	6.50%
Jan-20	70.90%	6.10%	13.50%	3.50%	6.00%
Apr-20	72.45%	6.05%	12.75%	3.25%	5.50%
Jul-20	74.00%	6.00%	12.00%	3.00%	5.00%

TSP L2010 Quarterly Allocation Targets

	G Fund	F Fund	C Fund	S Fund	I Fund
Jan-10	70.90%	6.10%	13.50%	3.50%	6.00%
Apr-10	72.45%	6.05%	12.75%	3.25%	5.50%
Jul-10	74.00%	6.00%	12.00%	3.00%	5.00%

TSP L Income Quarterly Allocation Targets

	G Fund	F Fund	C Fund	S Fund	I Fund
Jan-10	74.00%	6.00%	12.00%	3.00%	5.00%

Appendix C. Fitted TSP Individual Fund Distribution of Returns

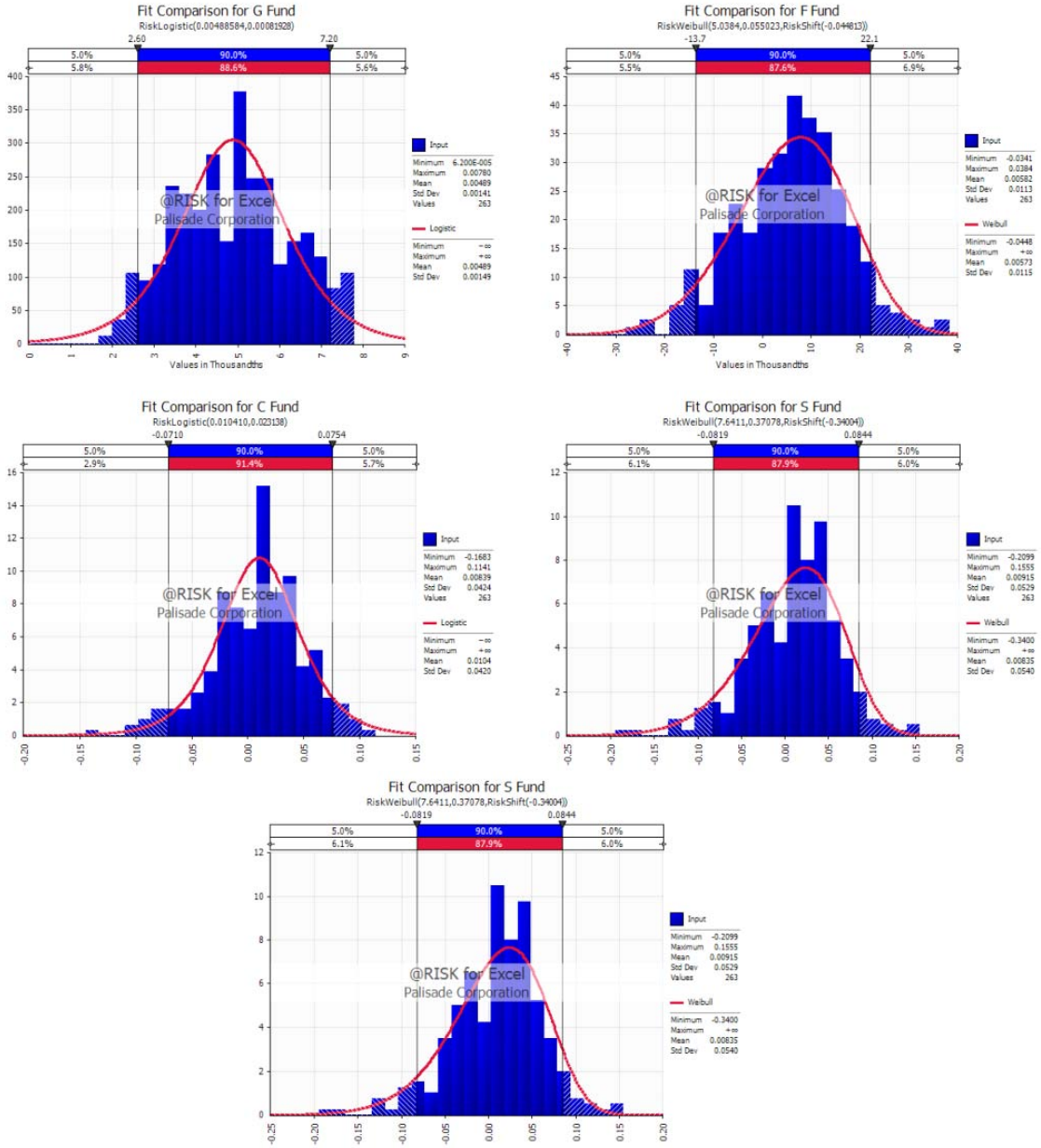

Figure 9: Fitted TSP Individual Funds Distribution of Returns

Appendix D. Expected DRO (CLPM) and TSP L Fund Portfolio Values at Retirement (BY10$)

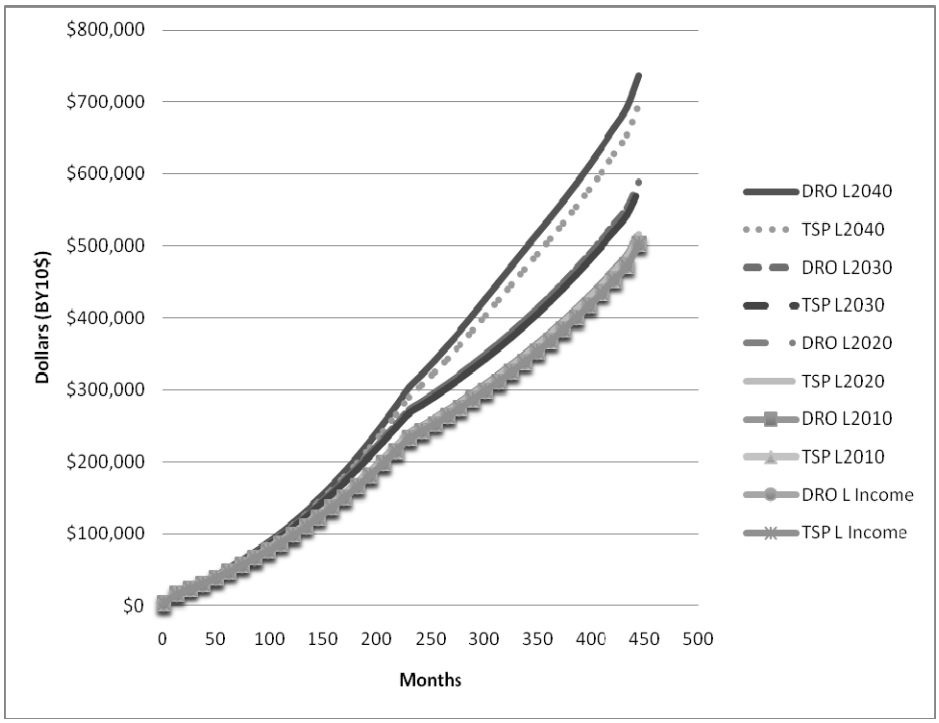

Figure 10: 22 year old L Fund Simulation: Expected Portfolio Values (BY10$)

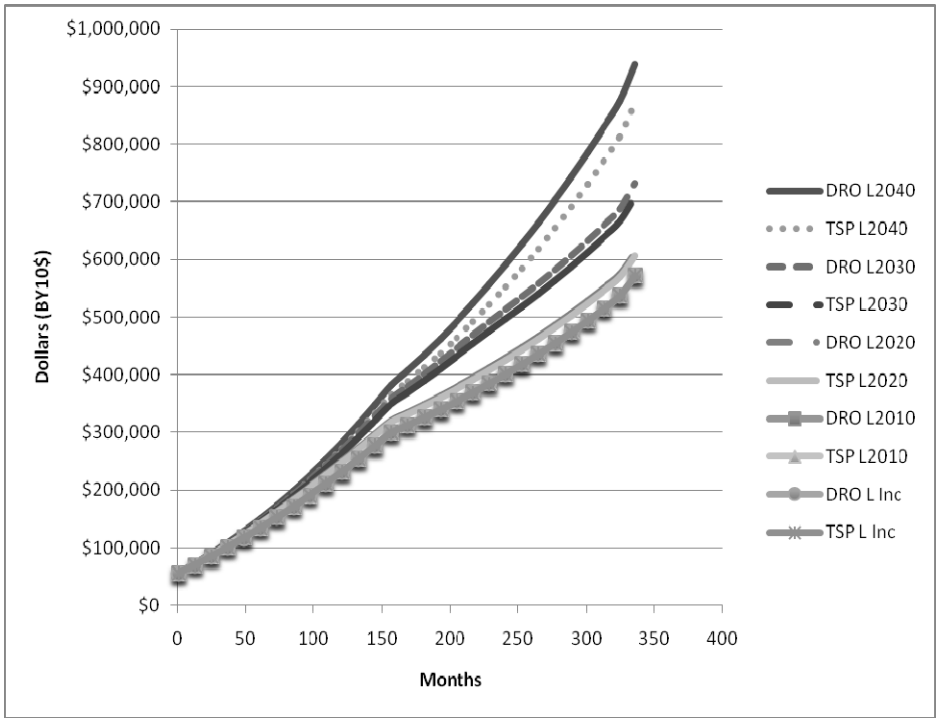

Figure 11: 32 year old L Fund Simulation: Expected Portfolio Values (BY10$, $54,287 Initial Balance)

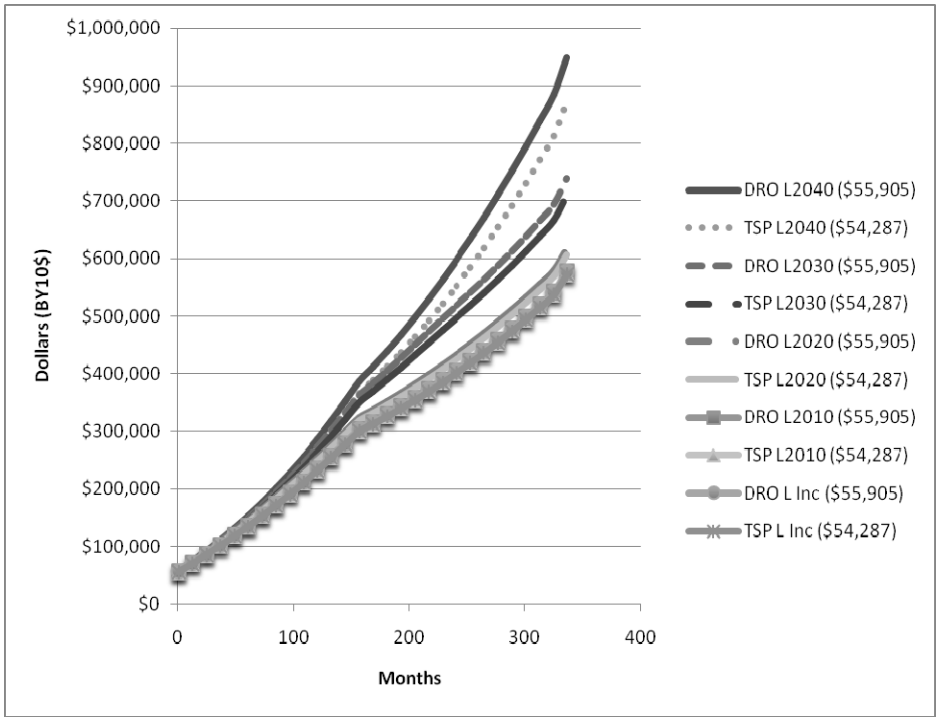

Figure 12: 32 year old L Fund Simulation: Expected Portfolio Values (BY10$, $55,905 v. $54,287 Initial Balance

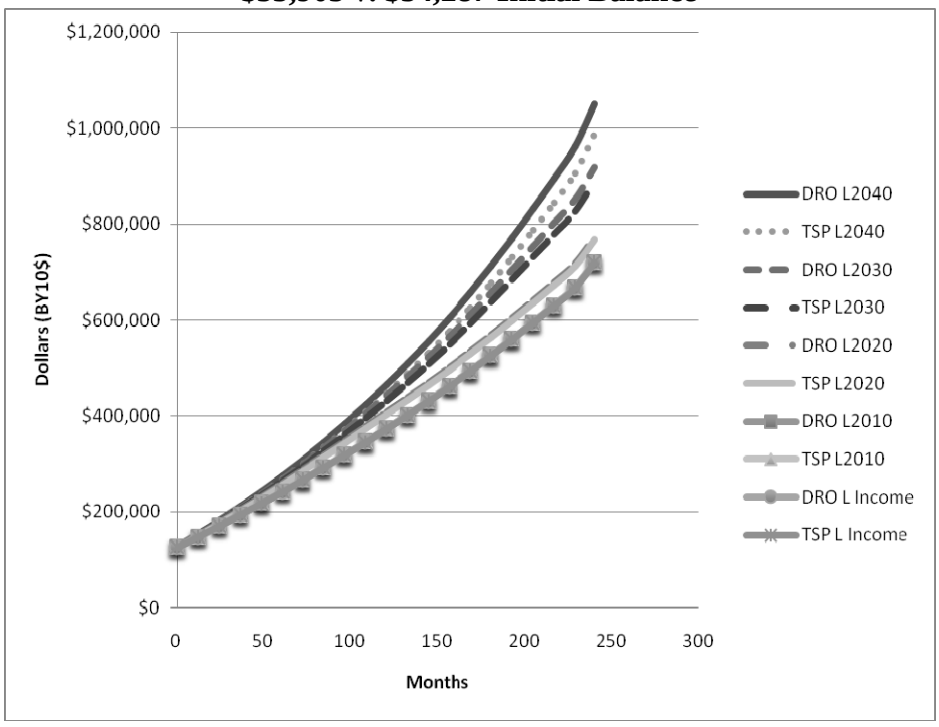

Figure 13: 42 year old L Fund Simulation: Expected Portfolio Values (BY10$)

Appendix E. Simulation Results Probability Tables

Table 19: 22 Year Old L Fund Simulation Probability Table

	22 year old Simulation Probability Table									
Dollar Goal (TY$)	DRO L2040	TSP L2040	DRO L2030	TSP L2030	DRO L2020	TSP L2020	DRO L2010	TSP L2010	DRO L Income	TSP L Income
$500,000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$600,000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$700,000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$800,000	100.00%	99.94%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$900,000	99.96%	99.80%	99.98%	99.88%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$1,000,000	99.82%	99.16%	99.90%	99.58%	99.92%	99.78%	99.90%	99.62%	99.90%	99.62%
$1,100,000	99.16%	97.38%	99.06%	97.70%	98.82%	97.54%	98.26%	96.60%	98.26%	96.60%
$1,200,000	97.72%	95.22%	95.96%	93.28%	91.68%	88.68%	87.66%	85.14%	87.66%	85.14%
$1,300,000	95.20%	91.52%	88.08%	83.80%	72.44%	68.78%	62.68%	61.22%	62.68%	61.24%
$1,400,000	91.26%	85.40%	76.58%	69.72%	45.26%	44.30%	33.40%	33.82%	33.40%	33.78%
$1,500,000	85.38%	77.76%	60.32%	53.72%	21.34%	22.02%	12.14%	14.42%	12.14%	14.42%
$1,600,000	78.02%	69.10%	43.16%	38.54%	8.04%	9.32%	3.26%	4.38%	3.26%	4.36%
$1,700,000	70.10%	59.90%	28.74%	25.54%	2.18%	3.00%	0.90%	0.92%	0.90%	0.92%
$1,800,000	61.24%	50.44%	16.54%	16.34%	0.72%	0.62%	0.20%	0.16%	0.20%	0.16%
$1,900,000	52.48%	42.30%	9.42%	9.16%	0.10%	0.20%	0.00%	0.00%	0.00%	0.00%
$2,000,000	43.82%	35.08%	4.70%	5.12%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,100,000	35.38%	28.06%	2.54%	2.72%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,200,000	27.74%	22.08%	1.14%	1.18%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,300,000	21.82%	16.48%	0.66%	0.52%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,400,000	16.50%	12.76%	0.30%	0.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,500,000	12.38%	9.56%	0.12%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,600,000	9.22%	7.28%	0.04%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,700,000	6.66%	5.34%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,800,000	5.20%	3.86%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,900,000	3.94%	2.68%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,000,000	2.86%	2.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,100,000	2.12%	1.38%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,200,000	1.60%	0.98%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,300,000	1.20%	0.64%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,400,000	0.84%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,500,000	0.62%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,600,000	0.50%	0.14%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,700,000	0.28%	0.14%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,800,000	0.20%	0.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,900,000	0.14%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$4,000,000	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 20: 32 Year Old L Fund Simulation ($54,287 Initial Balance) Probability Table

	32 year old Simulation Probability Table ($54,287 TSP Balance)									
Dollar Goal (TY$)	DRO L2040	TSP L2040	DRO L2030	TSP L2030	DRO L2020	TSP L2020	DRO L2010	TSP L2010	DRO L Income	TSP L Income
$500,000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$600,000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$700,000	100.00%	99.94%	100.00%	99.98%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$800,000	99.94%	99.72%	99.94%	99.84%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$900,000	99.74%	98.90%	99.80%	98.92%	99.84%	99.54%	99.92%	99.74%	99.92%	99.72%
$1,000,000	98.94%	96.74%	98.46%	95.82%	97.52%	95.50%	96.16%	94.50%	96.14%	94.48%
$1,100,000	97.44%	93.70%	94.44%	90.18%	86.88%	82.76%	75.58%	73.50%	75.50%	73.40%
$1,200,000	94.56%	89.38%	86.58%	79.94%	63.18%	59.14%	39.28%	39.32%	39.28%	39.36%
$1,300,000	90.04%	83.16%	75.08%	67.22%	35.24%	34.82%	11.12%	14.08%	11.08%	14.02%
$1,400,000	84.86%	76.08%	60.96%	52.74%	15.24%	16.06%	2.06%	3.06%	2.06%	3.02%
$1,500,000	78.10%	67.82%	47.62%	40.26%	4.92%	5.92%	0.16%	0.54%	0.16%	0.52%
$1,600,000	70.44%	59.56%	33.82%	28.72%	1.26%	2.08%	0.00%	0.08%	0.00%	0.08%
$1,700,000	62.68%	51.00%	22.84%	19.82%	0.28%	0.52%	0.00%	0.02%	0.00%	0.02%
$1,800,000	54.60%	43.10%	14.28%	12.90%	0.02%	0.16%	0.00%	0.00%	0.00%	0.00%
$1,900,000	46.74%	36.32%	8.96%	8.14%	0.00%	0.06%	0.00%	0.00%	0.00%	0.00%
$2,000,000	39.70%	30.02%	5.32%	4.96%	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%
$2,100,000	33.24%	24.60%	2.84%	3.10%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%
$2,200,000	26.96%	19.94%	1.50%	1.78%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,300,000	21.82%	15.84%	0.78%	1.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,400,000	17.42%	12.74%	0.34%	0.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,500,000	13.68%	9.80%	0.18%	0.28%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,600,000	10.84%	7.38%	0.12%	0.16%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,700,000	8.48%	5.68%	0.06%	0.10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,800,000	6.74%	4.28%	0.06%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,900,000	4.90%	3.36%	0.02%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,000,000	3.90%	2.88%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,100,000	2.94%	2.28%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,200,000	2.16%	1.74%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,300,000	1.64%	1.28%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,400,000	1.08%	1.00%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,500,000	0.88%	0.66%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,600,000	0.70%	0.50%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,700,000	0.40%	0.40%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,800,000	0.30%	0.28%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,900,000	0.22%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$4,000,000	0.16%	0.16%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 21: 32 Year Old L Fund Simulation ($55,905 Initial Balance) Probability Table

	32 year old Simulation Probability Table ($55,905 TSP Balance)									
Dollar Goal (TY$)	**DRO L2040**	**TSP L2040**	**DRO L2030**	**TSP L2030**	**DRO L2020**	**TSP L2020**	**DRO L2010**	**TSP L2010**	**DRO L Income**	**TSP L Income**
$500,000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$600,000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$700,000	100.00%	99.96%	100.00%	99.98%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$800,000	99.94%	99.72%	99.96%	99.84%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$900,000	99.74%	98.96%	99.80%	99.06%	99.94%	99.64%	99.96%	99.76%	99.96%	99.76%
$1,000,000	99.14%	97.00%	98.60%	96.08%	98.00%	96.30%	96.84%	95.22%	96.82%	95.28%
$1,100,000	97.62%	94.04%	95.04%	90.76%	88.98%	84.36%	78.76%	76.56%	78.78%	76.50%
$1,200,000	94.84%	89.88%	87.58%	81.30%	66.16%	62.14%	43.04%	43.10%	43.04%	42.98%
$1,300,000	90.56%	84.20%	76.66%	68.72%	38.90%	37.86%	13.66%	16.12%	13.64%	16.06%
$1,400,000	85.64%	77.04%	62.84%	54.70%	17.28%	17.88%	2.84%	3.64%	2.80%	3.60%
$1,500,000	79.16%	69.16%	49.66%	42.06%	5.84%	7.02%	0.24%	0.72%	0.24%	0.74%
$1,600,000	71.60%	60.86%	35.70%	30.24%	1.62%	2.48%	0.00%	0.08%	0.00%	0.08%
$1,700,000	63.94%	52.08%	24.34%	21.58%	0.40%	0.62%	0.00%	0.04%	0.00%	0.04%
$1,800,000	55.74%	44.44%	15.72%	14.22%	0.04%	0.24%	0.00%	0.00%	0.00%	0.00%
$1,900,000	48.30%	37.38%	9.76%	9.04%	0.00%	0.06%	0.00%	0.00%	0.00%	0.00%
$2,000,000	41.08%	31.34%	5.88%	5.46%	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%
$2,100,000	34.84%	25.64%	3.52%	3.44%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%
$2,200,000	28.58%	20.86%	1.78%	2.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,300,000	22.90%	16.70%	0.98%	1.14%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,400,000	18.58%	13.42%	0.38%	0.64%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,500,000	14.56%	10.42%	0.20%	0.32%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,600,000	11.48%	7.94%	0.14%	0.22%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,700,000	9.16%	5.94%	0.08%	0.12%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,800,000	7.22%	4.78%	0.06%	0.06%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,900,000	5.46%	3.50%	0.02%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,000,000	4.20%	3.08%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,100,000	3.20%	2.34%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,200,000	2.40%	1.86%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,300,000	1.80%	1.44%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,400,000	1.26%	1.06%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,500,000	0.96%	0.76%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,600,000	0.78%	0.58%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,700,000	0.46%	0.42%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,800,000	0.34%	0.30%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,900,000	0.26%	0.26%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$4,000,000	0.18%	0.16%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 22: 42 Year Old L Fund Simulation Probability Table

	42 year old Simulation Probability Table									
Dollar Goal (TY$)	**DRO L2040**	**TSP L2040**	**DRO L2030**	**TSP L2030**	**DRO L2020**	**TSP L2020**	**DRO L2010**	**TSP L2010**	**DRO L Income**	**TSP L Income**
$500,000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$600,000	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$700,000	100.00%	99.94%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$800,000	100.00%	99.80%	100.00%	99.94%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$900,000	99.64%	99.04%	99.90%	99.46%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
$1,000,000	98.78%	97.16%	98.94%	97.50%	99.50%	98.46%	99.52%	99.14%	99.52%	99.14%
$1,100,000	96.64%	93.34%	96.36%	92.52%	93.10%	89.78%	87.98%	86.54%	87.98%	86.40%
$1,200,000	92.10%	87.68%	89.06%	84.58%	72.40%	68.40%	46.96%	45.68%	46.86%	45.48%
$1,300,000	86.72%	79.84%	78.82%	71.58%	42.52%	39.74%	10.70%	12.10%	10.58%	12.02%
$1,400,000	78.52%	69.26%	64.52%	56.94%	17.20%	18.02%	1.08%	1.68%	1.06%	1.68%
$1,500,000	68.78%	59.12%	49.52%	42.46%	5.66%	6.62%	0.08%	0.02%	0.08%	0.02%
$1,600,000	58.58%	48.06%	34.78%	29.44%	1.54%	1.98%	0.00%	0.00%	0.00%	0.00%
$1,700,000	48.72%	39.04%	23.64%	20.52%	0.38%	0.60%	0.00%	0.00%	0.00%	0.00%
$1,800,000	39.06%	30.02%	14.72%	13.24%	0.12%	0.12%	0.00%	0.00%	0.00%	0.00%
$1,900,000	31.34%	23.10%	9.28%	8.36%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,000,000	24.42%	17.52%	5.96%	5.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,100,000	18.14%	13.26%	3.38%	3.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,200,000	13.68%	9.48%	1.80%	1.84%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,300,000	10.28%	7.02%	0.96%	1.20%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,400,000	7.66%	5.00%	0.46%	0.56%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,500,000	5.64%	3.68%	0.22%	0.24%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,600,000	4.08%	2.46%	0.16%	0.16%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,700,000	2.88%	1.88%	0.12%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,800,000	2.08%	1.40%	0.08%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$2,900,000	1.42%	1.04%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,000,000	0.96%	0.72%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,100,000	0.68%	0.46%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,200,000	0.54%	0.26%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,300,000	0.34%	0.18%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,400,000	0.28%	0.14%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,500,000	0.20%	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,600,000	0.18%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,700,000	0.14%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,800,000	0.14%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$3,900,000	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
$4,000,000	0.04%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Appendix F: Simulation One-Way Sensitivity Analysis (TY$)

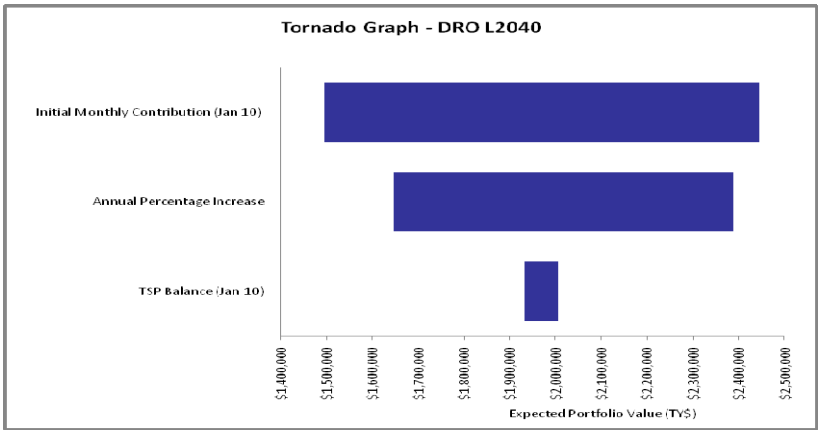

Figure 14: 22 year old L Fund Simulation: DRO (CLPM) L2040 Tornado Graph (TY$)

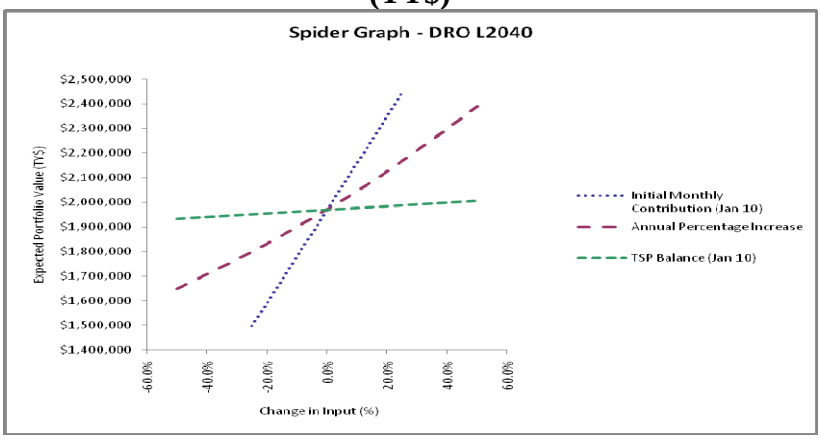

Figure 15: 22 year old L Fund Simulation: DRO (CLPM) L2040 Spider Graph (TY$)

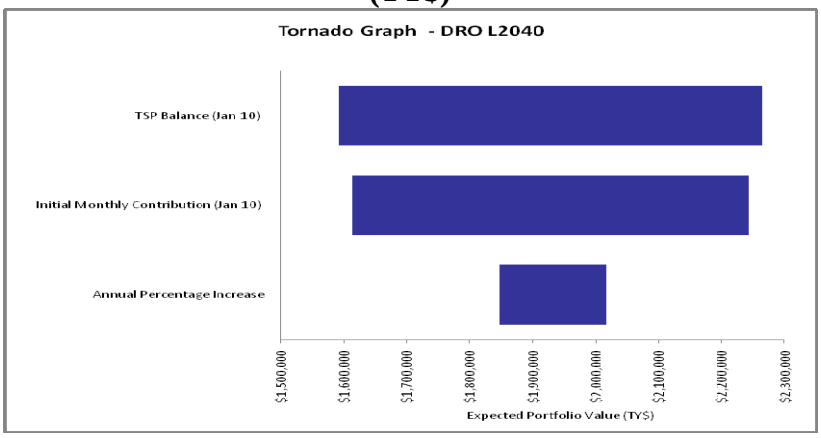

Figure 16: 32 year old L Fund Simulation: DRO (CLPM) L2040 Tornado Graph (TY$, $54,287 Initial Balance)

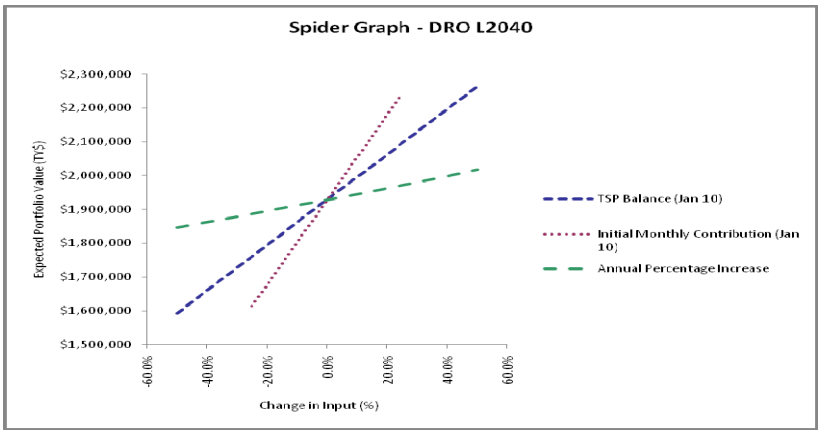

Figure 17: 32 year old L Fund Simulation: DRO (CLPM) L2040 Tornado Graph (TY$, $54,287 Initial Balance)

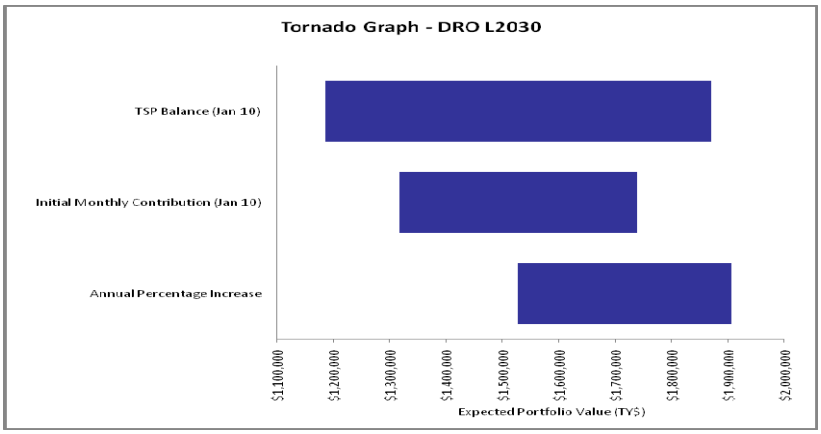

Figure 18: 42 year old L Fund Simulation: DRO (CLPM) L2030 Tornado Graph (TY$)

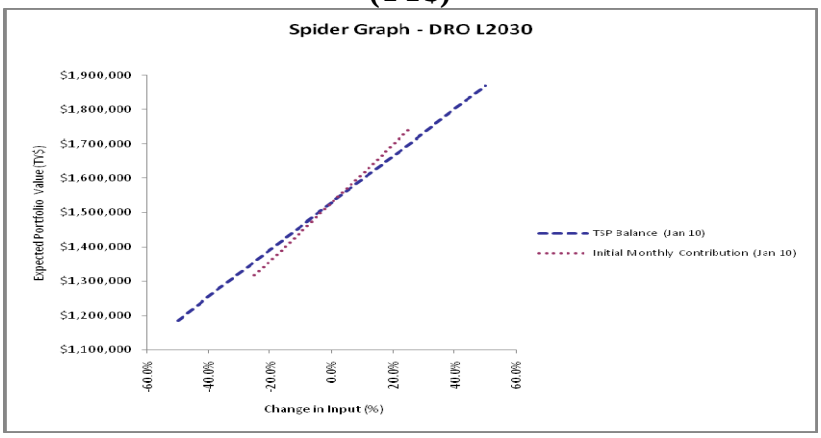

Figure 19: 42 year old L Fund Simulation (CLPM) L2030 Spider Graph (TY$)

Appendix G: Simulation Two-Way Sensitivity Analysis (TY$)

Table 23: 22 Year Old DRO (CLPM) L2040 Two-Way Data Table

TY$		TSP Balance (Jan 10)									
		$1,500	$1,833	$2,167	$2,500	$2,833	$3,167	$3,500	$3,833	$4,167	$4,500
Annual Percentage Increase	2.5%	$1,610,658	$1,618,881	$1,627,103	$1,635,326	$1,643,549	$1,651,771	$1,659,994	$1,668,217	$1,676,439	$1,684,662
	3.1%	$1,675,242	$1,683,465	$1,691,687	$1,699,910	$1,708,133	$1,716,355	$1,724,578	$1,732,801	$1,741,023	$1,749,246
	3.6%	$1,743,643	$1,751,865	$1,760,088	$1,768,311	$1,776,533	$1,784,756	$1,792,979	$1,801,201	$1,809,424	$1,817,647
	4.2%	$1,816,113	$1,824,336	$1,832,559	$1,840,781	$1,849,004	$1,857,227	$1,865,449	$1,873,672	$1,881,895	$1,890,117
	4.7%	$1,892,925	$1,901,147	$1,909,370	$1,917,593	$1,925,815	$1,934,038	$1,942,261	$1,950,483	$1,958,706	$1,966,929
	5.3%	$1,974,366	$1,982,589	$1,990,811	$1,999,034	$2,007,257	$2,015,479	$2,023,702	$2,031,925	$2,040,147	$2,048,370
	5.8%	$2,060,747	$2,068,969	$2,077,192	$2,085,415	$2,093,637	$2,101,860	$2,110,083	$2,118,305	$2,126,528	$2,134,751
	6.4%	$2,152,396	$2,160,619	$2,168,842	$2,177,064	$2,185,287	$2,193,510	$2,201,732	$2,209,955	$2,218,178	$2,226,400
	6.9%	$2,249,668	$2,257,891	$2,266,113	$2,274,336	$2,282,559	$2,290,781	$2,299,004	$2,307,226	$2,315,449	$2,323,672
	7.5%	$2,352,938	$2,361,160	$2,369,383	$2,377,606	$2,385,828	$2,394,051	$2,402,274	$2,410,496	$2,418,719	$2,426,942

TY$		TSP Balance (Jan 10)									
		$1,500	$1,833	$2,167	$2,500	$2,833	$3,167	$3,500	$3,833	$4,167	$4,500
Initial Monthly Contribution (Jan 10)	$375	$1,459,036	$1,467,259	$1,475,482	$1,483,704	$1,491,927	$1,500,150	$1,508,372	$1,516,595	$1,524,818	$1,533,040
	$403	$1,564,372	$1,572,595	$1,580,818	$1,589,040	$1,597,263	$1,605,486	$1,613,708	$1,621,931	$1,630,153	$1,638,376
	$431	$1,669,708	$1,677,931	$1,686,153	$1,694,376	$1,702,599	$1,710,821	$1,719,044	$1,727,267	$1,735,489	$1,743,712
	$458	$1,775,044	$1,783,267	$1,791,489	$1,799,712	$1,807,935	$1,816,157	$1,824,380	$1,832,603	$1,840,825	$1,849,048
	$486	$1,880,380	$1,888,602	$1,896,825	$1,905,048	$1,913,270	$1,921,493	$1,929,716	$1,937,938	$1,946,161	$1,954,384
	$514	$1,985,716	$1,993,938	$2,002,161	$2,010,384	$2,018,606	$2,026,829	$2,035,052	$2,043,274	$2,051,497	$2,059,720
	$542	$2,091,052	$2,099,274	$2,107,497	$2,115,720	$2,123,942	$2,132,165	$2,140,388	$2,148,610	$2,156,833	$2,165,056
	$569	$2,196,387	$2,204,610	$2,212,833	$2,221,055	$2,229,278	$2,237,501	$2,245,723	$2,253,946	$2,262,169	$2,270,391
	$597	$2,301,723	$2,309,946	$2,318,169	$2,326,391	$2,334,614	$2,342,837	$2,351,059	$2,359,282	$2,367,505	$2,375,727
	$625	$2,407,059	$2,415,282	$2,423,505	$2,431,727	$2,439,950	$2,448,173	$2,456,395	$2,464,618	$2,472,841	$2,481,063

TY$		Initial Monthly Contribution (Jan 10)									
		$375	$403	$431	$458	$486	$514	$542	$569	$597	$625
Annual Percentage Increase	2.5%	$1,254,246	$1,341,671	$1,429,097	$1,516,522	$1,603,947	$1,691,373	$1,778,798	$1,866,223	$1,953,649	$2,041,074
	3.1%	$1,302,684	$1,393,697	$1,484,711	$1,575,724	$1,666,737	$1,757,751	$1,848,764	$1,939,777	$2,030,791	$2,121,804
	3.6%	$1,353,984	$1,448,798	$1,543,611	$1,638,425	$1,733,238	$1,828,051	$1,922,865	$2,017,678	$2,112,491	$2,207,305
	4.2%	$1,408,337	$1,507,177	$1,606,016	$1,704,856	$1,803,695	$1,902,535	$2,001,375	$2,100,214	$2,199,054	$2,297,893
	4.7%	$1,465,946	$1,569,053	$1,672,160	$1,775,266	$1,878,373	$1,981,480	$2,084,587	$2,187,694	$2,290,800	$2,393,907
	5.3%	$1,527,027	$1,634,658	$1,742,290	$1,849,921	$1,957,552	$2,065,184	$2,172,815	$2,280,446	$2,388,078	$2,495,709
	5.8%	$1,591,812	$1,704,243	$1,816,673	$1,929,103	$2,041,533	$2,153,964	$2,266,394	$2,378,824	$2,491,254	$2,603,685
	6.4%	$1,660,550	$1,778,072	$1,895,594	$2,013,115	$2,130,637	$2,248,159	$2,365,681	$2,483,203	$2,600,725	$2,718,247
	6.9%	$1,733,503	$1,856,429	$1,979,355	$2,102,281	$2,225,207	$2,348,133	$2,471,059	$2,593,985	$2,716,910	$2,839,836
	7.5%	$1,810,956	$1,939,619	$2,068,282	$2,196,945	$2,325,608	$2,454,271	$2,582,934	$2,711,598	$2,840,261	$2,968,924

Table 24: 32 Year Old DRO (CLPM) L2040 Two-Way Data Table ($54,287 TSP Balance)

TY$		TSP Balance (Jan 10)									
		$27,144	$33,175	$39,207	$45,239	$51,271	$57,303	$63,335	$69,367	$75,399	$81,431
Annual Percentage Increase	1.4%	$1,511,797	$1,586,324	$1,660,851	$1,735,378	$1,809,905	$1,884,433	$1,958,960	$2,033,487	$2,108,014	$2,182,541
	1.7%	$1,529,215	$1,603,743	$1,678,270	$1,752,797	$1,827,324	$1,901,851	$1,976,378	$2,050,905	$2,125,432	$2,199,959
	2.0%	$1,546,980	$1,621,507	$1,696,035	$1,770,562	$1,845,089	$1,919,616	$1,994,143	$2,068,670	$2,143,197	$2,217,724
	2.3%	$1,565,099	$1,639,626	$1,714,153	$1,788,681	$1,863,208	$1,937,735	$2,012,262	$2,086,789	$2,161,316	$2,235,843
	2.6%	$1,583,580	$1,658,107	$1,732,634	$1,807,161	$1,881,688	$1,956,215	$2,030,742	$2,105,269	$2,179,796	$2,254,323
	2.9%	$1,602,429	$1,676,956	$1,751,483	$1,826,011	$1,900,538	$1,975,065	$2,049,592	$2,124,119	$2,198,646	$2,273,173
	3.2%	$1,621,656	$1,696,183	$1,770,710	$1,845,237	$1,919,764	$1,994,291	$2,068,818	$2,143,345	$2,217,873	$2,292,400
	3.5%	$1,641,268	$1,715,795	$1,790,322	$1,864,849	$1,939,376	$2,013,903	$2,088,430	$2,162,957	$2,237,484	$2,312,011
	3.8%	$1,661,273	$1,735,800	$1,810,327	$1,884,854	$1,959,381	$2,033,908	$2,108,435	$2,182,962	$2,257,489	$2,332,016
	4.1%	$1,681,679	$1,756,206	$1,830,733	$1,905,260	$1,979,787	$2,054,314	$2,128,841	$2,203,368	$2,277,896	$2,352,423

TY$		TSP Balance (Jan 10)									
		$27,144	$33,175	$39,207	$45,239	$51,271	$57,303	$63,335	$69,367	$75,399	$81,431
Initial Monthly Contribution (Jan 10)	$750	$1,278,561	$1,353,088	$1,427,616	$1,502,143	$1,576,670	$1,651,197	$1,725,724	$1,800,251	$1,874,778	$1,949,305
	$806	$1,348,427	$1,422,954	$1,497,481	$1,572,008	$1,646,536	$1,721,063	$1,795,590	$1,870,117	$1,944,644	$2,019,171
	$861	$1,418,293	$1,492,820	$1,567,347	$1,641,874	$1,716,401	$1,790,928	$1,865,456	$1,939,983	$2,014,510	$2,089,037
	$917	$1,488,159	$1,562,686	$1,637,213	$1,711,740	$1,786,267	$1,860,794	$1,935,321	$2,009,849	$2,084,376	$2,158,903
	$972	$1,558,025	$1,632,552	$1,707,079	$1,781,606	$1,856,133	$1,930,660	$2,005,187	$2,079,714	$2,154,241	$2,228,769
	$1,028	$1,627,891	$1,702,418	$1,776,945	$1,851,472	$1,925,999	$2,000,526	$2,075,053	$2,149,580	$2,224,107	$2,298,634
	$1,083	$1,697,757	$1,772,284	$1,846,811	$1,921,338	$1,995,865	$2,070,392	$2,144,919	$2,219,446	$2,293,973	$2,368,500
	$1,139	$1,767,623	$1,842,150	$1,916,677	$1,991,204	$2,065,731	$2,140,258	$2,214,785	$2,289,312	$2,363,839	$2,438,366
	$1,194	$1,837,489	$1,912,016	$1,986,543	$2,061,070	$2,135,597	$2,210,124	$2,284,651	$2,359,178	$2,433,705	$2,508,232
	$1,250	$1,907,354	$1,981,882	$2,056,409	$2,130,936	$2,205,463	$2,279,990	$2,354,517	$2,429,044	$2,503,571	$2,578,098

TY$		Initial Monthly Contribution (Jan 10)									
		$750	$806	$861	$917	$972	$1,028	$1,083	$1,139	$1,194	$1,250
Annual Percentage Increase	1.4%	$1,553,063	$1,618,420	$1,683,777	$1,749,134	$1,814,490	$1,879,847	$1,945,204	$2,010,561	$2,075,918	$2,141,275
	1.7%	$1,566,126	$1,632,451	$1,698,776	$1,765,100	$1,831,425	$1,897,750	$1,964,074	$2,030,399	$2,096,724	$2,163,048
	2.0%	$1,579,450	$1,646,762	$1,714,073	$1,781,385	$1,848,696	$1,916,008	$1,983,320	$2,050,631	$2,117,943	$2,185,254
	2.3%	$1,593,039	$1,661,357	$1,729,676	$1,797,994	$1,866,312	$1,934,630	$2,002,948	$2,071,267	$2,139,585	$2,207,903
	2.6%	$1,606,900	$1,676,244	$1,745,589	$1,814,934	$1,884,279	$1,953,624	$2,022,969	$2,092,314	$2,161,659	$2,231,004
	2.9%	$1,621,037	$1,691,429	$1,761,821	$1,832,213	$1,902,605	$1,972,997	$2,043,389	$2,113,781	$2,184,173	$2,254,566
	3.2%	$1,635,457	$1,706,917	$1,778,377	$1,849,837	$1,921,298	$1,992,758	$2,064,218	$2,135,678	$2,207,139	$2,278,599
	3.5%	$1,650,166	$1,722,715	$1,795,265	$1,867,815	$1,940,365	$2,012,914	$2,085,464	$2,158,014	$2,230,564	$2,303,113
	3.8%	$1,665,169	$1,738,830	$1,812,491	$1,886,153	$1,959,814	$2,033,475	$2,107,136	$2,180,797	$2,254,458	$2,328,120
	4.1%	$1,680,474	$1,755,269	$1,830,064	$1,904,859	$1,979,653	$2,054,448	$2,129,243	$2,204,038	$2,278,833	$2,353,628

Table 25: 42 Year Old DRO (CLPM) L2030 Two-Way Data Table

TY$		TSP Balance (Jan 10)									
		$62,500	$76,389	$90,278	$104,167	$118,056	$131,944	$145,833	$159,722	$173,611	$187,500
Annual Percentage Increase	0.0%	$1,186,040	$1,261,978	$1,337,916	$1,413,854	$1,489,792	$1,565,730	$1,641,668	$1,717,606	$1,793,544	$1,869,482
	0.6%	$1,219,015	$1,294,953	$1,370,891	$1,446,829	$1,522,767	$1,598,705	$1,674,643	$1,750,581	$1,826,519	$1,902,457
	1.1%	$1,253,911	$1,329,849	$1,405,787	$1,481,725	$1,557,663	$1,633,601	$1,709,539	$1,785,477	$1,861,415	$1,937,353
	1.7%	$1,290,855	$1,366,793	$1,442,731	$1,518,669	$1,594,607	$1,670,545	$1,746,483	$1,822,421	$1,898,359	$1,974,297
	2.2%	$1,329,984	$1,405,922	$1,481,860	$1,557,798	$1,633,736	$1,709,674	$1,785,612	$1,861,550	$1,937,488	$2,013,426
	2.8%	$1,371,444	$1,447,382	$1,523,320	$1,599,258	$1,675,196	$1,751,134	$1,827,072	$1,903,010	$1,978,948	$2,054,885
	3.3%	$1,415,391	$1,491,329	$1,567,267	$1,643,205	$1,719,143	$1,795,081	$1,871,019	$1,946,957	$2,022,895	$2,098,833
	3.9%	$1,461,992	$1,537,930	$1,613,868	$1,689,806	$1,765,744	$1,841,682	$1,917,620	$1,993,558	$2,069,496	$2,145,434
	4.4%	$1,511,426	$1,587,364	$1,663,302	$1,739,240	$1,815,178	$1,891,116	$1,967,054	$2,042,992	$2,118,930	$2,194,868
	5.0%	$1,563,884	$1,639,822	$1,715,760	$1,791,698	$1,867,635	$1,943,573	$2,019,511	$2,095,449	$2,171,387	$2,247,325

TY$		TSP Balance (Jan 10)									
		$62,500	$76,389	$90,278	$104,167	$118,056	$131,944	$145,833	$159,722	$173,611	$187,500
Initial Monthly Contribution (Jan 10)	$1,031	$974,960	$1,050,898	$1,126,836	$1,202,774	$1,278,712	$1,354,650	$1,430,588	$1,506,526	$1,582,464	$1,658,402
	$1,108	$1,021,867	$1,097,805	$1,173,743	$1,249,681	$1,325,619	$1,401,557	$1,477,495	$1,553,433	$1,629,371	$1,705,309
	$1,184	$1,068,773	$1,144,711	$1,220,649	$1,296,587	$1,372,525	$1,448,463	$1,524,401	$1,600,339	$1,676,277	$1,752,215
	$1,260	$1,115,680	$1,191,618	$1,267,556	$1,343,494	$1,419,432	$1,495,370	$1,571,308	$1,647,246	$1,723,184	$1,799,122
	$1,337	$1,162,587	$1,238,525	$1,314,463	$1,390,401	$1,466,339	$1,542,277	$1,618,215	$1,694,152	$1,770,090	$1,846,028
	$1,413	$1,209,493	$1,285,431	$1,361,369	$1,437,307	$1,513,245	$1,589,183	$1,665,121	$1,741,059	$1,816,997	$1,892,935
	$1,490	$1,256,400	$1,332,338	$1,408,276	$1,484,214	$1,560,152	$1,636,090	$1,712,028	$1,787,966	$1,863,904	$1,939,842
	$1,566	$1,303,306	$1,379,244	$1,455,182	$1,531,120	$1,607,058	$1,682,996	$1,758,934	$1,834,872	$1,910,810	$1,986,748
	$1,642	$1,350,213	$1,426,151	$1,502,089	$1,578,027	$1,653,965	$1,729,903	$1,805,841	$1,881,779	$1,957,717	$2,033,655
	$1,719	$1,397,120	$1,473,058	$1,548,996	$1,624,934	$1,700,872	$1,776,810	$1,852,748	$1,928,686	$2,004,624	$2,080,562

TY$		Initial Monthly Contribution (Jan 10)									
		$1,031	$1,108	$1,184	$1,260	$1,337	$1,413	$1,490	$1,566	$1,642	$1,719
Annual Percentage Increase	0.0%	$1,316,681	$1,363,588	$1,410,494	$1,457,401	$1,504,308	$1,551,214	$1,598,121	$1,645,027	$1,691,934	$1,738,841
	0.6%	$1,341,413	$1,390,151	$1,438,890	$1,487,628	$1,536,367	$1,585,105	$1,633,844	$1,682,583	$1,731,321	$1,780,060
	1.1%	$1,367,584	$1,418,262	$1,468,939	$1,519,616	$1,570,293	$1,620,971	$1,671,648	$1,722,325	$1,773,002	$1,823,679
	1.7%	$1,395,292	$1,448,022	$1,500,752	$1,553,481	$1,606,211	$1,658,941	$1,711,670	$1,764,400	$1,817,130	$1,869,859
	2.2%	$1,424,639	$1,479,542	$1,534,446	$1,589,349	$1,644,253	$1,699,156	$1,754,060	$1,808,963	$1,863,867	$1,918,770
	2.8%	$1,455,734	$1,512,941	$1,570,148	$1,627,354	$1,684,561	$1,741,768	$1,798,975	$1,856,182	$1,913,388	$1,970,595
	3.3%	$1,488,694	$1,548,343	$1,607,991	$1,667,639	$1,727,287	$1,786,936	$1,846,584	$1,906,232	$1,965,881	$2,025,529
	3.9%	$1,523,645	$1,585,882	$1,648,120	$1,710,357	$1,772,594	$1,834,832	$1,897,069	$1,959,306	$2,021,543	$2,083,781
	4.4%	$1,560,721	$1,625,704	$1,690,688	$1,755,672	$1,820,655	$1,885,639	$1,950,622	$2,015,606	$2,080,590	$2,145,573
	5.0%	$1,600,064	$1,667,962	$1,735,860	$1,803,758	$1,871,656	$1,939,553	$2,007,451	$2,075,349	$2,143,247	$2,211,145

Appendix H: DRO (CLPM) Simulation MAR (τ) Sensitivity Analysis

Table 26: 0.000% MAR (τ) DRO (CLPM) L Fund Initial Target Allocations

L Fund	G	F	C	S	I	CLPM	Return
L2040	0.00%	43.00%	57.00%	0.00%	0.00%	1.58%	0.49%
L2030	0.00%	51.00%	49.00%	0.00%	0.00%	1.37%	0.46%
L2020	0.00%	62.00%	38.00%	0.00%	0.00%	1.09%	0.42%
L2010	0.00%	77.00%	22.00%	1.00%	0.00%	0.75%	0.35%
L Income	54.00%	36.00%	8.00%	2.00%	0.00%	0.24%	0.25%

Table 27: 0.075% MAR (τ) DRO (CLPM) L Fund Initial Target Allocations

L Fund	G	F	C	S	I	CLPM	Return
L2040	0.00%	43.00%	57.00%	0.00%	0.00%	1.61%	0.49%
L2030	0.00%	51.00%	49.00%	0.00%	0.00%	1.40%	0.46%
L2020	0.00%	62.00%	38.00%	0.00%	0.00%	1.12%	0.42%
L2010	0.00%	77.00%	22.00%	1.00%	0.00%	0.78%	0.35%
L Income	55.00%	36.00%	8.00%	1.00%	0.00%	0.25%	0.24%

Table 28: 0.150% MAR (τ) DRO (CLPM) L Fund Initial Target Allocations

L Fund	G	F	C	S	I	CLPM	Return
L2040	0.00%	43.00%	57.00%	0.00%	0.00%	1.64%	0.49%
L2030	0.00%	51.00%	49.00%	0.00%	0.00%	1.43%	0.46%
L2020	0.00%	62.00%	38.00%	0.00%	0.00%	1.15%	0.42%
L2010	0.00%	77.00%	22.00%	1.00%	0.00%	0.81%	0.35%
L Income	55.00%	35.00%	8.00%	2.00%	0.00%	0.30%	0.25%

Table 29: 0.225% MAR (τ) DRO (CLPM) L Fund Initial Target Allocations

L Fund	G	F	C	S	I	CLPM	Return
L2040	0.00%	43.00%	57.00%	0.00%	0.00%	1.67%	0.49%
L2030	0.00%	51.00%	49.00%	0.00%	0.00%	1.46%	0.46%
L2020	0.00%	62.00%	38.00%	0.00%	0.00%	1.18%	0.42%
L2010	1.00%	76.00%	22.00%	1.00%	0.00%	0.84%	0.35%
L Income	56.00%	34.00%	9.00%	1.00%	0.00%	0.32%	0.25%

Table 30: 0.300% MAR (τ) DRO (CLPM) L Fund Initial Target Allocations

L Fund	G	F	C	S	I	CLPM	Return
L2040	0.00%	43.00%	57.00%	0.00%	0.00%	1.70%	0.49%
L2030	0.00%	51.00%	49.00%	0.00%	0.00%	1.49%	0.46%
L2020	0.00%	62.00%	38.00%	0.00%	0.00%	1.21%	0.42%
L2010	3.00%	73.00%	23.00%	1.00%	0.00%	0.89%	0.36%
L Income	57.00%	33.00%	9.00%	1.00%	0.00%	0.35%	0.24%

Table 31: 0.375% MAR (τ) DRO (CLPM) L Fund Initial Target Allocations

L Fund	G	F	C	S	I	CLPM	Return
L2040	0.00%	43.00%	57.00%	0.00%	0.00%	1.74%	0.49%
L2030	0.00%	51.00%	49.00%	0.00%	0.00%	1.52%	0.46%
L2020	0.00%	62.00%	38.00%	0.00%	0.00%	1.25%	0.42%
L2010	5.00%	71.00%	23.00%	1.00%	0.00%	0.91%	0.35%
L Income	58.00%	31.00%	10.00%	1.00%	0.00%	0.39%	0.25%

Table 32: 0.450% MAR (τ) DRO (CLPM) L Fund Initial Target Allocations

L Fund	G	F	C	S	I	CLPM	Return
L2040	0.00%	43.00%	57.00%	0.00%	0.00%	1.77%	0.49%
L2030	0.00%	51.00%	49.00%	0.00%	0.00%	1.55%	0.46%
L2020	0.00%	62.00%	38.00%	0.00%	0.00%	1.28%	0.42%
L2010	7.00%	68.00%	24.00%	1.00%	0.00%	0.96%	0.36%
L Income	59.00%	30.00%	10.00%	1.00%	0.00%	0.42%	0.25%

Table 33: 0.525% MAR (τ) DRO (CLPM) L Fund Initial Target Allocations

L Fund	G	F	C	S	I	CLPM	Return
L2040	0.00%	43.00%	57.00%	0.00%	0.00%	1.80%	0.49%
L2030	0.00%	51.00%	49.00%	0.00%	0.00%	1.59%	0.46%
L2020	0.00%	62.00%	38.00%	0.00%	0.00%	1.31%	0.42%
L2010	8.00%	66.00%	26.00%	0.00%	0.00%	1.01%	0.36%
L Income	60.00%	29.00%	11.00%	0.00%	0.00%	0.45%	0.25%

Table 34: 0.600% MAR (τ) DRO (CLPM) L Fund Initial Target Allocations

L Fund	G	F	C	S	I	CLPM	Return
L2040	0.00%	43.00%	57.00%	0.00%	0.00%	1.83%	0.49%
L2030	0.00%	51.00%	49.00%	0.00%	0.00%	1.62%	0.46%
L2020	0.00%	62.00%	38.00%	0.00%	0.00%	1.35%	0.42%
L2010	10.00%	64.00%	26.00%	0.00%	0.00%	1.03%	0.36%
L Income	60.00%	28.00%	12.00%	0.00%	0.00%	0.51%	0.25%

Table 35: 0.675% MAR (τ) DRO (CLPM) L Fund Initial Target Allocations

L Fund	G	F	C	S	I	CLPM	Return
L2040	0.00%	43.00%	57.00%	0.00%	0.00%	1.87%	0.49%
L2030	0.00%	51.00%	49.00%	0.00%	0.00%	1.66%	0.46%
L2020	0.00%	62.00%	38.00%	0.00%	0.00%	1.38%	0.42%
L2010	11.00%	62.00%	27.00%	0.00%	0.00%	1.09%	0.36%
L Income	61.00%	27.00%	12.00%	0.00%	0.00%	0.54%	0.25%

Appendix I: DRO (CLPM) Model Validations: August 2005 – December 2009

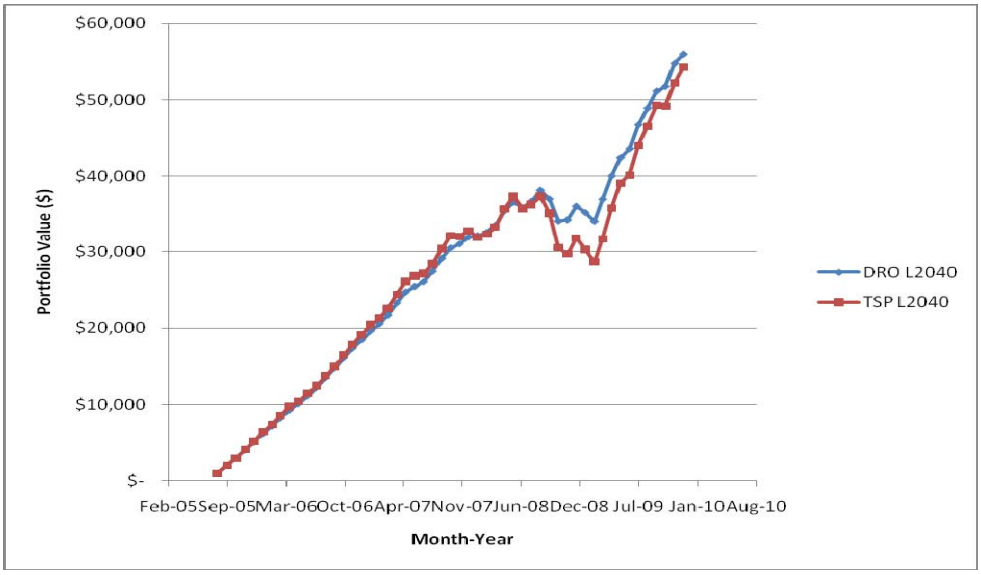

Figure 20: DRO (CLPM)/TSP L2040 Performance: Aug 05 - Dec 09

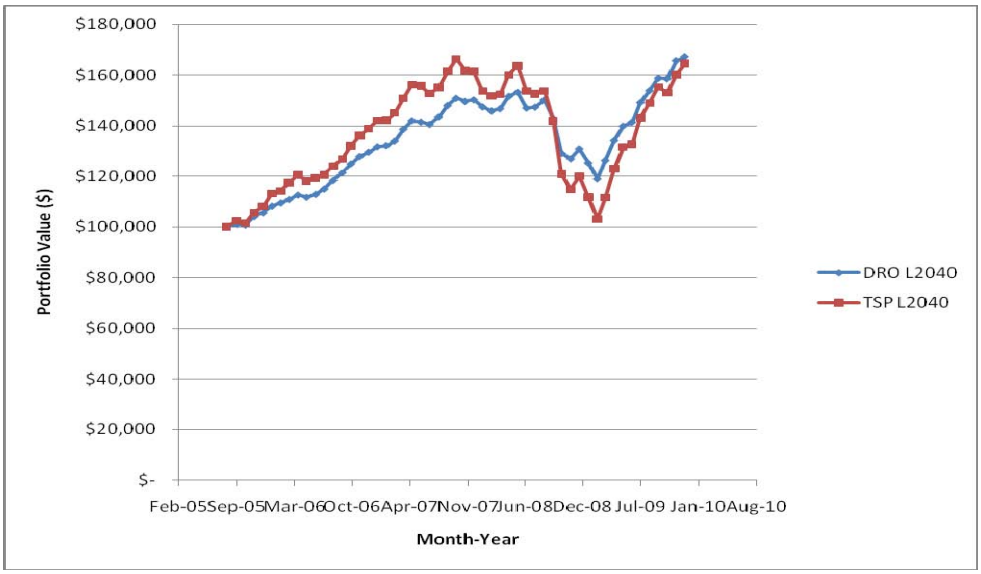

Figure 21: DRO (CLPM)/TSP L2040 Performance ($100K Initial Balance): Aug 05 - Dec 09

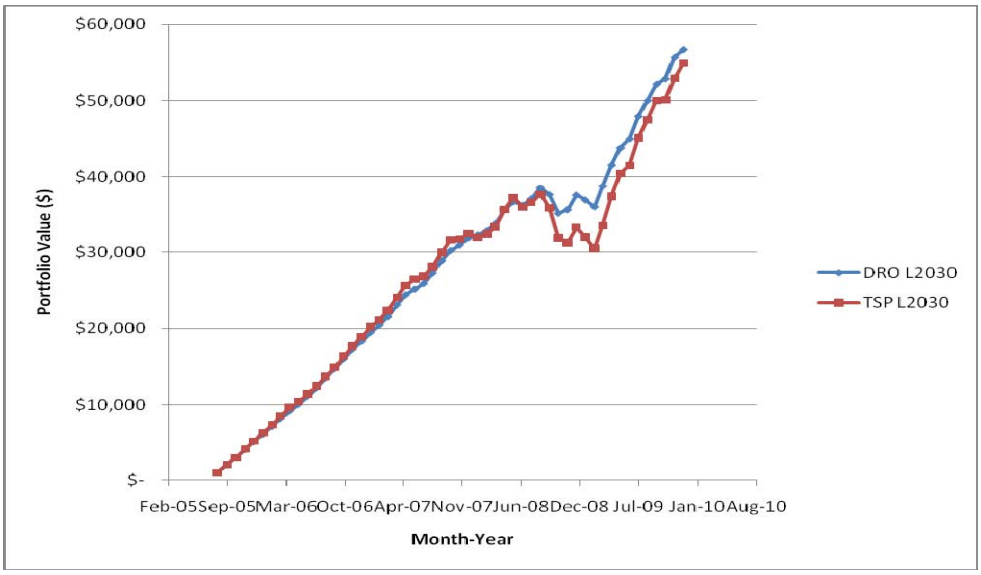

Figure 22: DRO (CLPM)/TSP L2030 Performance: Aug 05 - Dec 09

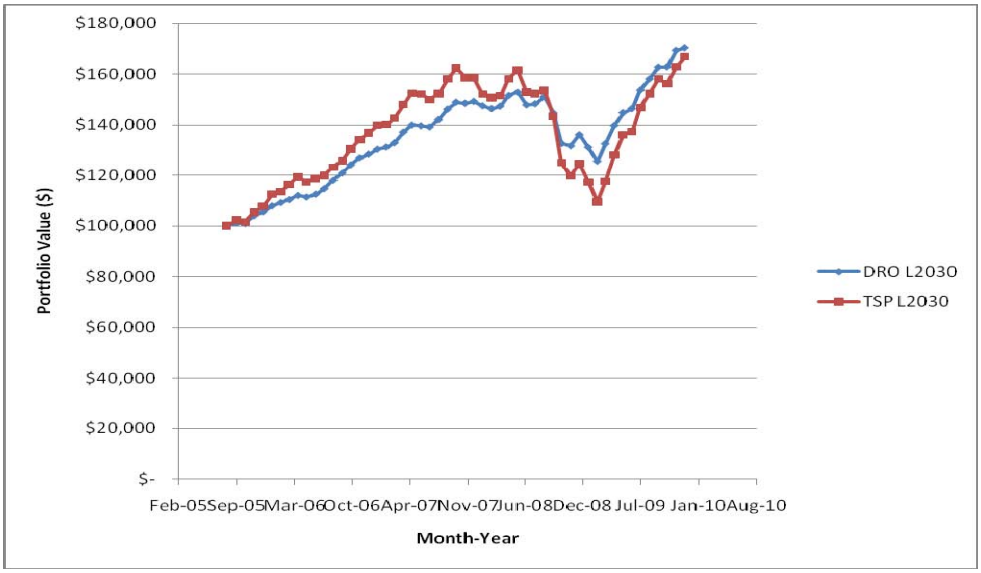

Figure 23: DRO (CLPM)/TSP L2030 Performance ($100K Initial Balance): Aug 05 - Dec 09

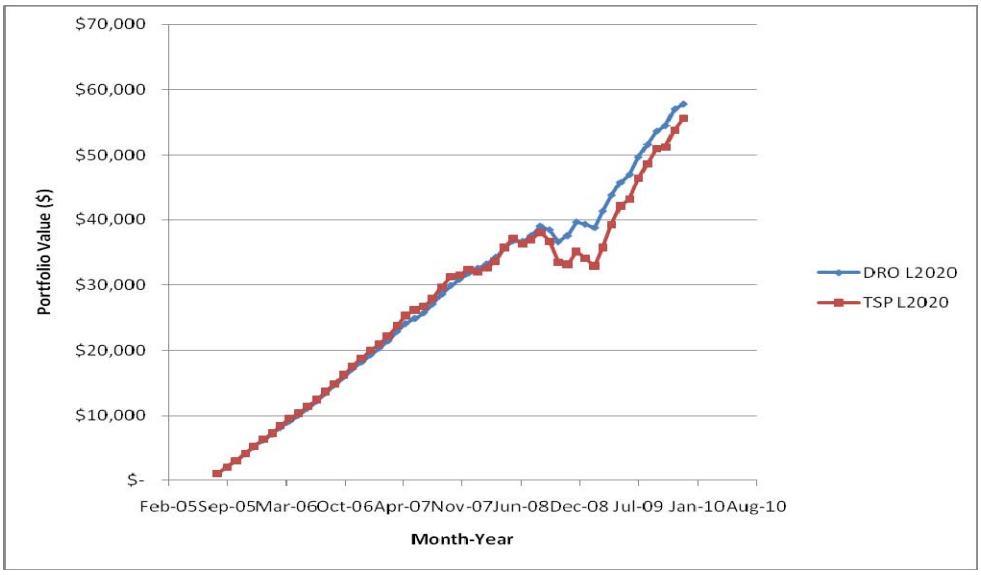

Figure 24: DRO (CLPM)/TSP L2020 Performance: Aug 05 - Dec 09

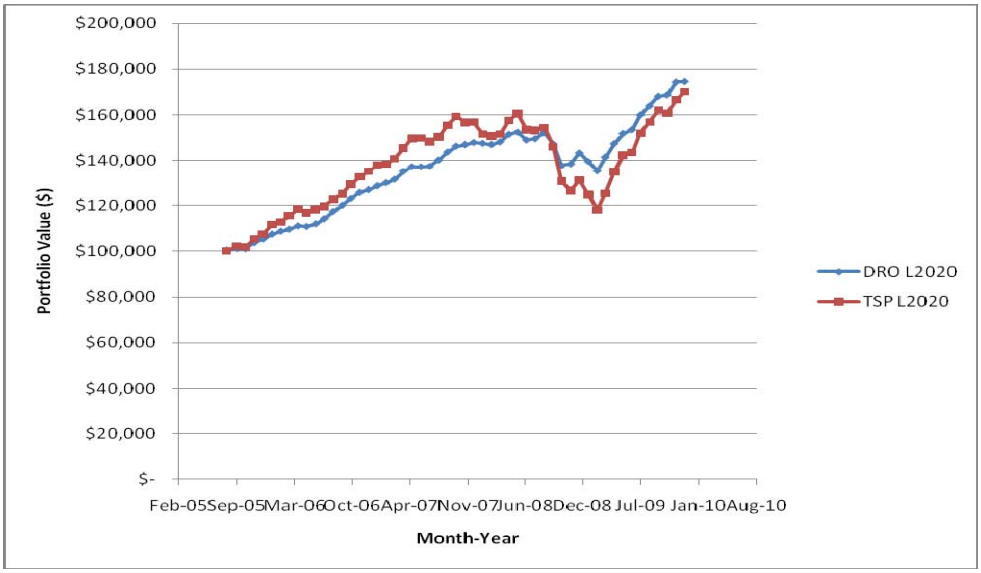

Figure 25: DRO (CLPM)/TSP L2020 Performance ($100K Initial Balance): Aug 05 - Dec 09

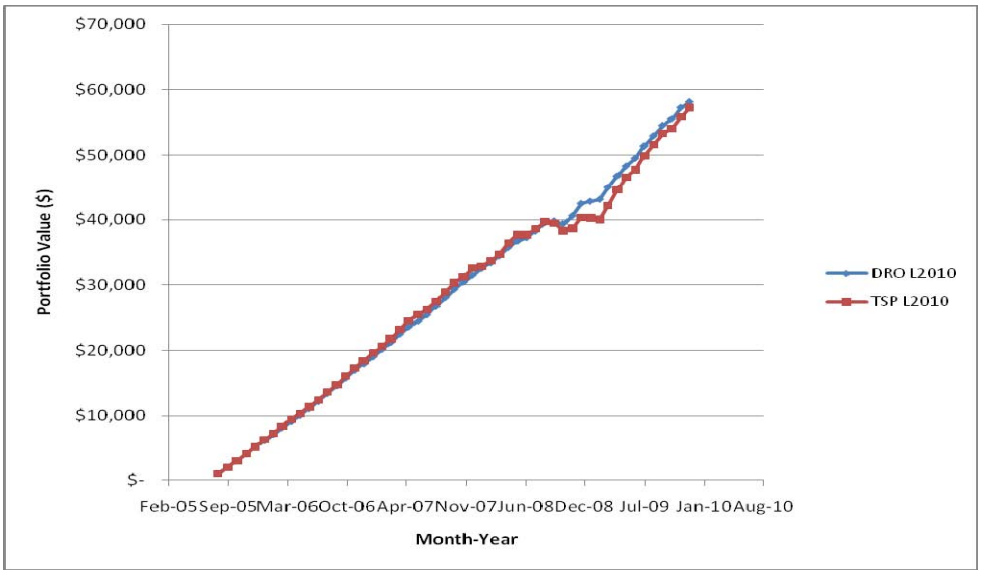

Figure 26: DRO (CLPM)/TSP L2010 Performance: Aug 05 - Dec 09

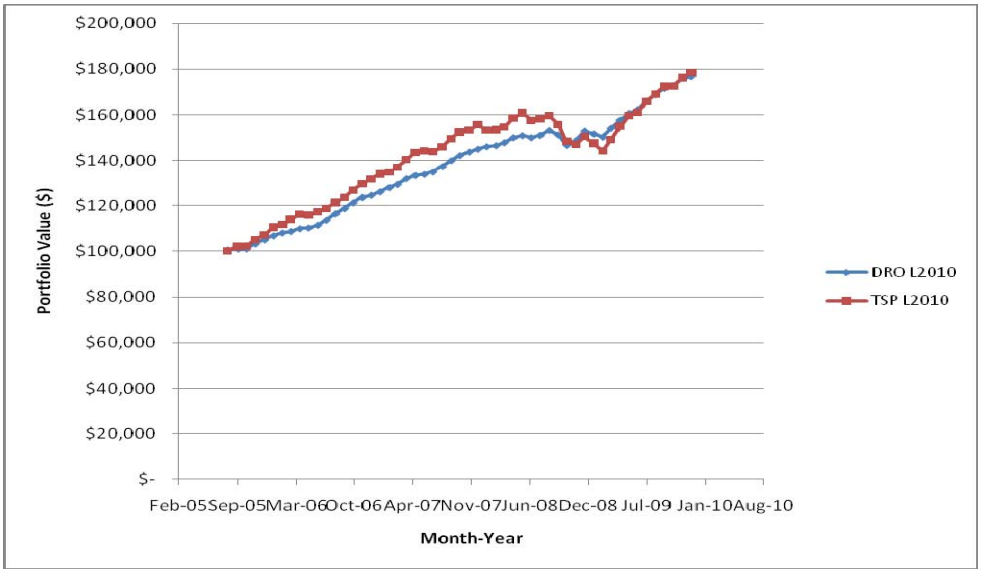

Figure 27: DRO (CLPM)/TSP L2010 Performance ($100K Initial Balance): Aug 05 - Dec 09

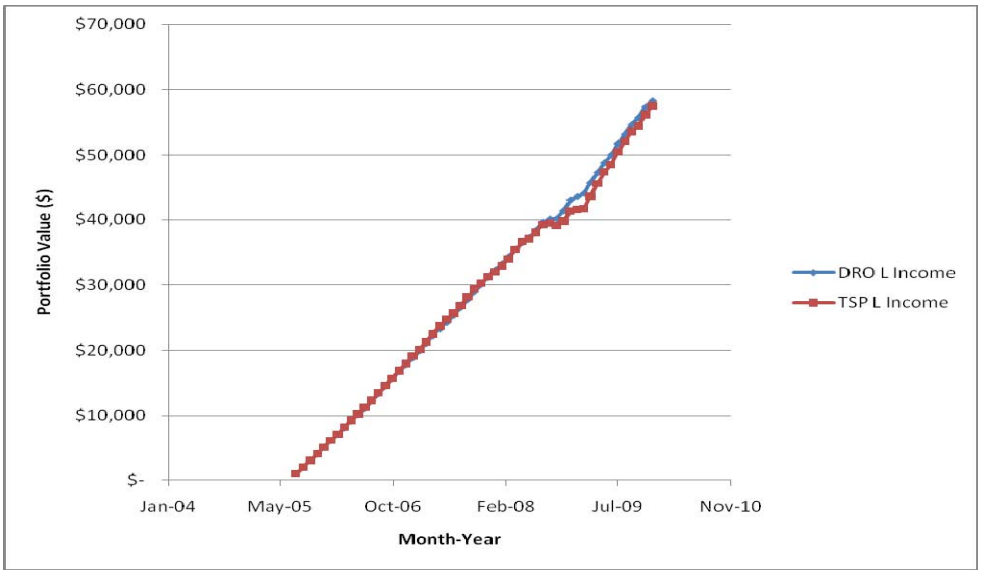

Figure 28: DRO (CLPM)/TSP L Income Performance: Aug 05 - Dec 09

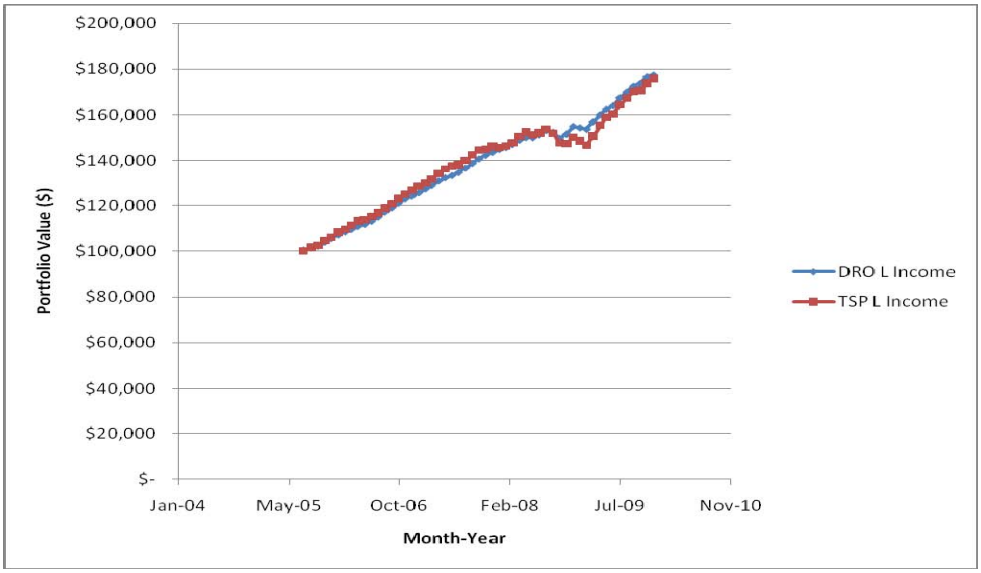

Figure 29: DRO (CLPM)/TSP L Income Performance ($100K Initial Balance): Aug 05 - Dec 09

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Vita

Captain Matthew Beck graduated from the United States Air Force Academy in June 2004 with a Bachelor of Science degree in Management. His first assignment was to Fairchild AFB, Washington, where he served as Flight Commander, Financial Services for the 92d Comptroller Squadron and 92d Air Refueling Wing. In August 2008, he entered the Cost Analysis Program, Graduate School of Engineering and Management, Air Force Institute of Technology. Following graduation, Captain Beck will be assigned to the Military Satellite Communications Wing at Los Angeles AFB, California.

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14. ABSTRACT
The Thrift Savings Plan (TSP), the defined benefit contribution plan for the US Government, introduced the asset allocation Lifecycle (L) Funds in August 2005. These funds seek to minimize risk and maximize expected portfolio return via mean-variance optimization (MVO). The purpose of this thesis is to investigate and examine the efficiency of the TSP L Funds and create alternative L Fund portfolios via downside risk optimization (DRO). Whereas MVO minimizes the portfolio variance (standard deviation), DRO seeks to minimize the risk below an investor's minimal acceptable return in the market, defined as the Co-Lower Partial Moment (CLPM). The research team compares the TSP and DRO (CLPM) L Fund expected portfolio values at retirement for three typical investors. The expected portfolio values are computed using @Risk software via Monte Carlo simulation of TSP individual fund monthly returns, the L Fund quarterly target allocations, and various investor inputs. The quantitative results and analysis of this evaluation determined that TSP participants realize higher expected portfolio values at retirement by investing into a DRO (CLPM) L Fund versus any of the TSP L Funds. To validate the findings, this thesis compares an investment stream in the L Funds from August 2005 through December 2009.

15. SUBJECT TERMS
Downside risk optimization, DRO, Mean-Variance Optimization, MVO, Modern Portfolio Theory, Post-Modern Portfolio Theory, asset allocation, Thrift Savings Plan, Lifecycle Fund

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